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THE AMERICAN SOCIETY OF
ICHTHYOLOGISTS AND HERPETOLOGISTS

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Published quarterly at Mt. Royal & Guilford Aves., Baltimore 2, Md. by the American Society of Ichthyologists and Herpetologists, The Florida State Museum, University of Florida, Gainesville, Florida. Entered as second class matter at the Post Office at Gainesville, Florida under the Act of August 24, 1912. Additional entry at the Post Office at Baltimore, Md. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized February 11, 1924.

Our Knowledge of the Bogturtle, *Clemmys muhlenbergi*, Surveyed and Augmented

A. J. BARTON AND JOHN W. PRICE, SR.

DURING the American Revolution, the German physician and naturalist, Schoepff, was in the United States as surgeon to a Hessian regiment. While in Philadelphia in 1778 he received several turtles from the early botanist, Heinrich Muhlenberg, of Lancaster, Pennsylvania. From among these specimens Schoepff (1801) described the new species, *Testudo muhlenbergii*. Fitzinger (1835) transferred it to the genus *Clemmys* where it stands today.

In the 154 years since the original description was published, the bogturtle has proved to be one of our rarest reptiles, and data regarding it have accumulated very slowly. This dearth of information and its scattered nature have led the present authors to survey the literature and to initiate certain observations on the colonies of this species in or near the type locality, preliminary results of which we now present.

RANGE.—Little of our attention has been devoted to the bogturtle's perplexingly scattered occurrence. In plotting known *C. muhlenbergi* localities (Fig. 1) we used Netting's summary (1927: Pl. 36) as a base. The following list consists of subsequently discovered localities that are based on the literature and on institutional and private collections: AMNH = American Museum of Natural History, ANSP = Academy of Natural Sciences of Philadelphia, CM = Carnegie Museum, FMNM = North Museum of Franklin and Marshall College, MNHS = Maryland Natural History Society, PRR = Patuxant Research Refuge, RJS = Robert J. Sim Collection, UD = University of Delaware, and USNM = United States National Museum. County names (in boldface) are followed by place names, each of which signifies the exact locality or its immediate vicinity.

DELAWARE.—**New Castle:** Marshallton (CM 26284); Newark (UD).

MARYLAND.—**Baltimore:** Grave Run Mills (MNHS 450). **Cecil:** below Conowingo Dam (Cooper, 1949); Elk Neck (CM 26287).

NEW JERSEY.—**Bergen:** Tenaft (AMNH 2173). **Burlington:** Bridgeboro (RJS); Marlton (Conant, 1953, in litt.). **Gloucester:** Turnersville (ANSP 17599); Mullica Hill (Conant, 1953, in litt.). **Mercer:** Princeton (USNM 029228); Hamilton Square (Conant, 1953, in litt.). **Middlesex:** Sayreville (AMNH 4791). **Monmouth:** Long Branch (Conant and Bailey, 1936); Hamilton (PRR); Allaire (Conant and Bailey, 1936). **Morris:** Chatham (Pope, 1946). **Ocean:** Lakehurst (Caulwell, 1932); New Egypt (AMNH 64655). **Union:** Plainfield (AMNH 58075).

NEW YORK.—**Dutchess:** Wingdale (Stewart, 1947). **Orange:** Queensboro (Davis, 1928). **Westchester:** Montrose; North Yonkers (Ashley, 1948).

PENNSYLVANIA.—**Berks:** Eshbach (Conant, 1953, in litt.). **Chester:** Ludwig's Corners; Berwyn (Conant, 1953, in litt.); Kennett Square (USNM 51413). **Crawford:** Hartstown (CM 4681). **Delaware:** Broomall (CM 13136); Glen Mills; Newton Square (Conant, 1953, in litt.). **Franklin:** Green Township (PRR H.10373-4). **Lancaster:** Hopeland (Lane, 1935); Brickerville (AMNH 74443-4); New Providence (CM 9065-6). **Lebanon:** Lebanon (Burger, 1933); Campbelltown (Conant, 1953, in litt.); Mt. Gretna (CM 9482-3); Colebrook (CM 8745-7); Penryn Station (USNM 132546). **Mercer:** Stoneboro (CM 4775). **Montgomery:** Schwenksville (Conant, 1953, in litt.); Sumneytown (Hudson, 1954). **York:** Wrightsville (FMNM 15).

We have omitted two records. Brady (1937) mentioned that Muhlenberg's turtle is "reported" between the old Chesapeake and Ohio Canal and the Potomac River in the vicinity of Plummer's Island, Maryland, but we agree with McCauley that it is best to await a more definite observation. Babcock (1917) extended the range of this species to include Newport, Rhode Island, on the basis of three specimens collected there by Alexander Agassiz in 1902. All subsequent reviewers (Schmidt, 1953: 92) have accepted his record. Mr. James Miller informed us, however, that the original label states that these specimens were taken in an artificial pond on an estate. Since this Rhode Island record has remained an isolated find for over 50 years, and in view of the strong suggestion in the original data that these turtles may have been introduced, it seems wise to delete all New England from the known range. Western Connecticut may yet yield the bog-



Fig. 1. Map of part of eastern United States, with locality records for *Clemmys muhlenbergi*. Triangles: Netting's (1927) citations; circles: sites discovered more recently.

turtle, but at present the easternmost station is Wingdale, New York ($\frac{3}{8}$ mile from the Connecticut border), reported by Stewart (1947).

Ditmars' record (1933: 284-5) for Staten Island has been retained despite some doubt as to its validity. Kauffeld (1949) did not list this turtle as part of the Staten Island fauna; Leng and Davis (1932: 52) recorded it with doubt; and Pope (1946: 104) specifically excluded Staten Island from the range. In view of the positive character of Ditmars' statement that "Most of the writer's specimens have been caught on Staten Island, N. Y. They were found along marshy borders of small, clear streams," we are unwilling to discard his record. Ashley tells us that the Montrose locality recorded by him (1948) has been destroyed by draining for a housing development.

HABITAT.—A number of authors have commented upon the habitat preferences of this species. Throughout its range, Muhlenberg's turtle exhibits an affinity for sphagnaceous bogs (Ashley, 1948; Carr, 1952: 131; Cramer, 1935; Netting, 1927; Pope, 1946: 104), swamps, and wet meadows traversed by clear, slow-moving streams (Carr, *loc. cit.*; Conant and Bailey, 1936; Ditmars, 1933: 285; 1936: 421; Fowler,

1907; Netting, *loc. cit.*; Pope, *loc. cit.*). The marl ponds of northern New York support a population of these reptiles (Wright, 1918a), and Fowler (1906) found one in a fresh-water pool at the edge of a tide marsh in Cape May County, New Jersey. We know of no exceptions to Conant and Bailey's suggestion (1936: 9) that a muddy bottom is a requirement of this species. An abundance of grassy or mossy cover is also characteristic of areas in which it is found. Bishop (1923) reported finding a bog-turtle in the entrance of a muskrat burrow. Trails such as those made by muskrats provide ideal situations for this species.

There is in Lancaster County, Pennsylvania, an area which embraces both of the primary ecological associations mentioned above: Gleisner's Swamp, $2\frac{1}{4}$ miles southeast of New Providence. The swamp covers a little more than 2 acres and, geologically, lies near the edge of the Martic overthrust in Wissahickon schist, of probable Pre-Cambrian age. The area is about equally divided by a small stream, a tributary to the south branch of Beaver Creek, running in a northeastern direction. Seepage from a number of small springs gives rise to tiny runs which enter the stream from both sides.

The section lying southeast of the stream is partially a wooded hillside sloping gently toward it. The lower segment of this area is covered with *Sphagnum* which has taken hold where the runs have fanned out into an anastomosis of rivulets while crossing the level area above the bed of the stream. Few trees are present here, although many moisture loving shrubs are well represented, including poison sumach (*Rhus vernix*), swamp magnolia (*Magnolia virginiana*), smooth alder (*Alnus rugosa*), Juneberry (*Amelanchier spicata*), swamp honeysuckle (*Rhododendron viscosum*), and swamp blueberry (*Vaccinium corymbosum*). Growing directly out of the moss, or the mica-flecked black muck beneath it, are sundew (*Drosera rotundifolia*), swamp orchids (*Arethusa bulbosa*, *Pogonia ophioglossoides*, *Limnium tuberosum*), innumerable grasses and sedges, several forms of *Lycopodium* and great banks of ferns. The intersecting rivulets cut their ways through the blanket of moss, and provide the runways along which the bog-turtle roams. The absence of trees assures a maximum of sun penetration, and the sponge-like action of the moss insures

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constant water evaporation, keeping the humidity high throughout the warm season.

The area northwest of the stream has no *Sphagnum*, trees or shrubs, but is composed of boggy meadow where cows are pastured. Grasses (especially bunch grasses), sedges, tearthumb (*Polygonum sagittatum*), and bur-reed (*Sparganium* sp.) are abundant. Islands of cattails (*Typha latifolia*) dot the area, indicating sections of permanent moisture. This northwest side is much wetter during the dry seasons than the part in which *Sphagnum* is found, likely because the flow of the feeder springs is more constant. The tussocks of clump grasses form the only dry places in the swamp. Surrounding each of these islands is a constant trickle of cold water meandering its way toward the main stream. Spasmodic attempts to drain this grassy half of Gleisner's Swamp have met with but little success, although they have slightly decreased its extent. The meadow mouse (*Microtus pennsylvanicus*) is abundant in the marsh, and its runways are everywhere seen tunneling through the grasses. Bogturtles are frequently found utilizing these runs.

That the swamp was at one time much more extensive is indicated by a deep layer of black carbonaceous earth exposed in the bank of the stream. The stream has now cut its channel to a level about 5 feet below the swamp, and is undoubtedly draining it much more effectively than in times past. The more rapid drainage explains the fact that there is no standing water in the marsh, and that the wet areas are limited to the sections affected by the *Sphagnum* and the reticulation of actual waterways.

BEHAVIOR.—The burrowing propensities of Muhlenberg's turtle have long been known (De Kay, 1842). While not so alert as *Chrysemys*, the bogturtle, when alarmed, rapidly buries itself into the mucky substrate with which it is characteristically associated. The burying motion sometimes consists of a head-first plunge into the muck, or more frequently, the same sidewise "falling leaf" motion used by desert reptiles to bury themselves in sand.

While the word "terrestrial" has been applied to this turtle (Babcock, 1919; De Kay, 1842; Roddy, 1928), we feel that it is misleading. The bogturtle is rather a frequenter of shallow, meandering water courses; its domed shell is only occasionally wet, but its feet are nearly

never dry. What we wish to point out is that *C. muhlenbergi* is not an aquatic turtle like *Chelydra* or *Trionyx*, nor even a pond turtle like *Chrysemys picta*.

Our observations indicate strongly that the bogturtle requires more heat to initiate and support activity than does *Chrysemys picta*, *Terrapene carolina* or *Clemmys guttata*; on many of the days warm and sunny enough to arouse these turtles, *C. muhlenbergi* remains in seclusion. Cramer (1941) has already mentioned its late hibernation, although Fowler (1907: 242) reported appearances as early as April 15 at Trenton, New Jersey. Our earliest record for spring is the first week of May and the latest fall observation is in the second week of October, in Lancaster County. Although large numbers of *Terrapene carolina* retire during the height of the summer's heat, from the surrounding fields and woodlands to the moisture of the swamps, and even here lie buried in cool muck, largely inactive during daylight hours, the bogturtle is to be found perched atop a tussock of grass, basking in direct sunlight. Even in midsummer it rarely becomes active before 10 A.M. Overnight and during cool, clouded spells, these turtles dig into the substrate. Ashley tells us of finding such specimens "about four inches deep." The pendant displayed by the bogturtle for higher temperatures leads us to suggest that the individual recorded by McCauley and Mansueti (1943) as being found in hardened mud was not necessarily aestivating. A combination of cool weather and falling water level might trap a turtle in such a situation, and dehydration might account for the torpid state which they described.

FOOD.—Only Surface (1907) has recorded the natural food of this species. One of the two specimens that he examined contained food. This consisted of 80 percent insects and 20 percent berries. The time of year was not mentioned. Our examination of the stomach contents of two adults taken in Lancaster County on June 13 revealed that they had been feeding primarily on insects, with one of the hairy lepidopterous larvae forming, in both, nearly one-half of the total intake. Coleopterous adults were the next commonest food item, followed by the fleshy seeds of a pondweed (*Potamogeton*). We are unable to explain the reason for the large number of seeds of a sedge

(*Carex*) contained in these turtles and in nine others subsequently examined, but these were too numerous and too uniformly present to be merely the result of accidental ingestion. Several larval cases of a caddisfly were found in both turtles. Also represented in both stomachs were the cocoons of a parasitic hymenopteran or dipteran probably ingested with their hosts. The upper intestine of one turtle contained the shells of several young snails (*Succinea ovalis*); that of the other had pieces of a millipede and a crane fly wing. The first of these also harbored three specimens of an oxyurid nematode, apparently related to the genus *Aplectana* (USNM Helm. Coll. 49324).

An examination of the feces of three other individuals taken at the same time and place showed the same high percentages of the remains of beetles and seeds of both *Carex* and *Potamogeton*. It is remarkable that there was no evidence that these turtles had fed upon wild strawberries (*Fragaria*), since this fruit grew in profusion on every side. Setae of earthworms were also completely absent from the digestive tracts of these five turtles, despite the fondness of captives for this invertebrate and its plentiful occurrence in the swamp. By far the most common item found in the feces of six turtles caught in mid-August was the exoskeleton of Japanese beetles (*Popillia japonica*).

It is apparent from the heterogeneity of this list that *C. mühlenbergi* feeds indiscriminately upon such aquatic and marsh dwelling invertebrates as are encountered. Availability seems to be the prime factor in its selection of animal food.

Pope (1936) wrote that captive bogturtles are omnivorous, thriving on raw meat, earthworms, mealworms, lettuce and berries. We have succeeded in keeping specimens healthy over prolonged periods of time on three feedings weekly. Two of these were of finely chopped whole fish or meat. The meat we fortified with a liberal pinch of bone meal and, if no fish were given, a little cod liver oil. The third meal consisted of fruit such as berries, pears, grapes or bananas.

We must contradict Brimley's statement (1943) that the bogturtle feeds only on land. We have observed individuals, both captive and free, feeding with equal ease under and above water. Food found on the very edge of a pool is devoured in air and is not taken under

water, but food found in shallow water is swallowed there, when merely raising the head would have brought it above the surface. No apparent preference for either mode is therefore displayed.

REPRODUCTION.—Mr. W. Stuart Cramer has kindly given us access to his unpublished notes on the courtship of this form. A captive pair was kept in an aquarium provided with a land area and a pool with a depth of more than twice the height of the turtles. Several days after capture, the male mounted the female under water, hooking the claws of his four feet under her marginals. He then thumped his plastron against her carapace several times, making a noise like two turtles shaken together in a bag. The female withdrew her head, and then the male moved forward without losing his footholds and, putting his head down in front of hers, blew bubbles of air and water through his nostrils. This procedure was repeated two or three times, and all the while he continued thumping lightly against her carapace. Next he moved back as far as was possible without losing the footholds and attempted to copulate. This entire performance was repeated several times at later dates, and each time both participants were entirely under water.

The only date we find for mating observed in nature is June 4, 1950. Mr. Henry L. Collins, III, discovered a pair in copulation in a ditch near a small spring-fed brook at Berwyn, Chester County, Pennsylvania. Cramer (1941) stated that females remain secluded in the mating season and that the males "must search for their mates."

The actual nesting of the bogturtle has never been observed, although Wright (1918a: 6) reported that a 90-mm. captive laid an egg in water on June 20, a second in sand on July 30, and had a third egg in the oviduct. Reed and Wright (1909) mentioned deposition of a clutch by another captive on July 20. A female (AMNH 74444) from Lancaster County, in our possession, laid eggs (AMNH 74445) on July 30 (1), August 14 (1), and August 21 (1). Lane (1935) on June 7 took five females from an alder swamp north of Hopeland, Lancaster County, Pennsylvania. The two smaller specimens, carapace lengths 67.5 and 70 mm., were evidently immature and contained no eggs. Because Lane's paper is unpublished, we quote

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directly the following data: "Specimens 3, 4 and 5 each contained three eggs. The eggs in 5 were not developed nearly as far as those in 3 and 4. These eggs were in the form of flattened spheres and had not yet entered the oviduct. The eggs in both 3 and 4 were in the oviducts, but the shells of those in 4 were thicker." Lane recorded the following measurements (in mm.):

No.	Carapace length	Egg a	Egg b	Egg c
3	85	29.9 × 14.8	28.3 × 14.6	28.3 × 14.1
4	87	29.9 × 15.5	31.1 × 15.2	30.7 × 15.8
5	88	16.2 × 13.5	16.0 × 13.7	13.2 × 11.2

On September 7, 1929, one of us (Price) visited Gleisner's Swamp and there discovered a nest of *Clemmys muhlenbergi*. His field notes state, "Saw four box turtles and fourteen Muhlenberg's turtles of various sizes. The day was very warm. Two spiral white objects [hatched turtle eggs] protruding from the moss led me to the nest, which was quite shallow and was four or five inches above the surface of the water in the swamp. It appeared that the female had buried herself in the moss and, after depositing the eggs, crawled out and allowed the moss to cover the eggs. Inside the nest was the third egg, with the young turtle just emerging from it. The young turtle was collected and is now in the North Museum, and still retains the egg tooth."

Cramer, also, found a nest containing three eggs (CM 7470) in Gleisner's Swamp on July 14, 1934. Since Cramer tells us that the high number of eggs suggested by him (1941) was not based on actual observation, we note that every clutch on record from any observer numbers three eggs. Cramer further informs us that the overwintering of young in the egg, and the retention by females of viable sperm from one mating to fertilize more than one clutch of eggs, both suggested in this paper, are not to be construed as valid data, but represent suppositions.

SEXUAL DIMORPHISM.—McCauley (1945: 157), Pope (1946: 104) and Wright (1918a) all agree that in the male bogturtle the tail is longer and thicker, and the plastron is more concave than in the female. We concur, and find that these characters alone are sufficient to determine the sex of adults. McCauley and Pope also have pointed out that the greatest

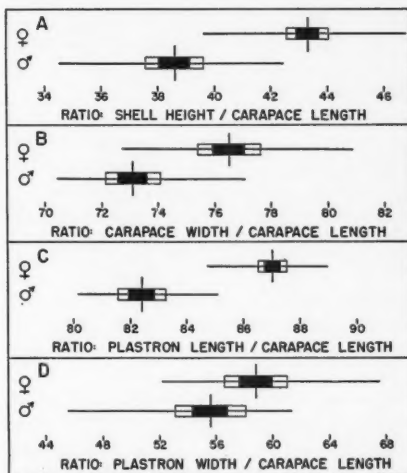


Fig. 2. Ratios of various shell measurements to carapace length.

Length of carapace is straight-line distance from anterior edge of precentral to posterior edge of postcentrals; height of shell is greatest vertical diameter; width of carapace is straight-line distance across widest part; width of plastron is distance between points of intersection of abdominal, pectoral and marginal laminae of either bridge. In graphs, horizontal line indicates range of variation; vertical line marks arithmetic mean; solid box covers one standard error on either side of mean; open box covers one additional standard error.

height of the female is proportionately greater than that of the male. Our data (Fig. 2 A), taken from a sample from Lancaster County, support their thesis and also closely agree with Dunn's observations (1917).

A statistical analysis of our data (Fig. 2 B) also supports Pope's contention that females are relatively wider across the carapace than males. Measured at the widest point (usually the flared lip above and anterior to the hind legs), the mean carapace width of nine females is 76.5 percent of its mean length; of eleven males, 73.1 percent. These values again closely approximate Dunn's.

It has not been demonstrated previously that the plastron of the female bogturtle is relatively longer than the male's (Fig. 2 C). This value was found to vary less with size than any other tested.

Males seem to attain the greater maximum carapace length. Of 51 adults of known sex from all over the range, in museums or recorded in the literature, the seven largest are males with straight-line lengths of 108, 100, 96

(2), 95 (2), and 94 mm. The largest of 29 females has a length of 94 mm. and the mean of the series is 87.5; the mean length of the 22 males is 89.8 mm.

The relative plastron width was not found to be correlated with sex. The mean plastron width for eight males forms 55.6 percent of the total length, and for ten females, 58.8 percent; but the standard error is so large (Fig. 2 D)

that the "t" test, where $t = \frac{M_1 - M_2}{\sigma_d}$, demon-

strated a probability of only about 10 to 1 that the correlation with sex is meaningful. Our statistical methods were taken from Snedecor (1946).

Our findings do not agree with McCauley, Pope and Wright's statements that the heads of males are relatively wider and (except McCauley) deeper than those of females. In the series examined by us the difference was of insufficient magnitude to be considered meaningful. Our observations also fail to confirm Wright's report that the notch at the rear of the plastron is consistently "sharper" in females than in males. Individual variation in our sample was so great that this alleged character had no significance. We are further unable to find sexual dimorphism in the diameter, length or position of claws on the forefeet.

SIZE AND GROWTH.—Werner (1925: 412) listed the maximum length attained by this species as 12 cm. Rust (1936), probably following the *Tierleben*, gave the same maximum. No references to specimens were offered in support of this high figure, and we feel that it very probably is a measurement taken over the curve of the shell. If this is so, it is about 16 percent too high, and the 120 mm. would apply to a specimen with a straight-line carapace length of about 103 mm.

The largest specimen to come to our attention has a straight-line carapace length of 108 mm., a carapace width of 76 mm., a plastron length and width of 83 and 61 mm., respectively, and a height of 40 mm. This turtle, a male, was collected at Wrightsville, York County, Pennsylvania, and is now in the North Museum of Franklin and Marshall College (FMNM 15). Ditmars (1936: 421) recorded a specimen, sex not stated, 4 inches (= 102 mm.) long, and we took a male (AMNH 74443) near Brickerville, Lancaster County,

with a carapace length of 100 mm. This latter specimen exhibited signs of senility, among which were a marked deposition of pigment in the head so dark as nearly to obliterate the temporal spots, and a greatly overdeveloped "tooth" on each side of the apex of the beak.

Few data are at hand regarding the growth rate of Muhlenberg's turtle. It is hoped that the recovery of marked individuals will soon shed light on this problem. One young male raised in captivity for us by Carl and Stephen Harwig registered the following increases (in mm.) when kept at room temperature, feeding the year around (first column of figures, measurements made September 2, 1951; second, measurements made December 28, 1953; third, percentage increase):

Carapace length	53.2	84	58
Carapace width	46.8	69	47
Plastron length	45.2	71	57
Plastron width	36.5	51	40
Shell height	...	31	...

Growth rings suggest that September, 1951, was the close of this turtle's second summer (age about 2 years). Lane's observations indicate that sexual maturity in the female is attained when the carapace is about 75 mm. long; it is probable, then, that maturity is reached about the fifth year.

ACKNOWLEDGEMENTS.—Our thanks are offered to Dr. Doris M. Cochran of the U. S. National Museum, Dr. M. Graham Netting and Mr. Neil D. Richmond of the Carnegie Museum, Mr. Roger Conant of the Philadelphia Zoological Society, and Mr. Charles M. Bogert of the American Museum of Natural History for the ready access afforded us to their respective collections and records; to Mr. Robert G. Ward of The Stony Brook School for drawing our charts and map; to Messrs. Harold Ashley, Roger Conant, Stuart Cramer and Harry Lane for use of their unpublished notes; and to Drs. L. K. Henry, J. J. Parodiz and George Wallace of the Carnegie Museum, and M. A. Cazier of the American Museum of Natural History for help in identifying stomach contents. Miss Betty Snyder rendered valuable clerical assistance.

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Observations on the Life History and Ecology of the Amphibians of the Athens Area, Georgia

BERNARD MARTOF

MUCH collecting of the herpetofauna has been done in the Athens area, but due to the transitory status of the collectors, only a few data pertaining to the Amphibia have been published. In fact, much repetition of effort has occurred over the years. In order to avert further repetition and, more importantly, to promote more exhaustive study of the local herpetofauna, this paper is presented. It is based on collections made in 1952 and 1953, during which years a total of 25 species of amphibians (14 salamanders and 11 salientians) were taken in the Athens area. Over two thousand specimens have been taken, and these have been placed in the University of Georgia collection. Several extensions of range, and notes on the life history and ecology of the amphibians of the Athens area are included in this report.

The term "Athens area" designates a somewhat rectangular region of approximately 1,300 square miles located just east of the north-central part of Georgia. It includes six counties—Barrow, Clarke, Jackson, Madison, Oconee, and Oglethorpe—with the city of Athens located near the center. All the counties of this group lie wholly within the Piedmont Plateau. Here the general elevation ranges from 500 to 900 feet above sea level, the surface sloping gently towards the southeast. The topography is typical of the Piedmont in that it is hilly and dissected by streams. Most of the larger streams have cut their beds about 100 feet below the old plateau.

The Athens area is drained chiefly by the Oconee River which passes through its central part. The Apalachee and Broad rivers form its southwestern and northeastern borders, respectively, and provide the drainage of those sections.

The climate is characterized by short and mild winters, and long and hot summers. The mean annual temperature is about 62°F., the extremes ranging from 108° to -3°. The average annual rainfall is about 49 inches. Usually two periods of moderately heavy rainfall culminate in February-March and July,

respectively, with intervening dry seasons occurring in May and November. Winds are generally light and variable in direction.

The Athens area is principally an agricultural region, with cotton and corn the chief crops. About 85 percent of the area has been cleared for farming and grazing. Almost all the original timber has been cut; that remaining is mainly second-growth loblolly (*Pinus taeda*) and shortleaf pine (*P. echinata*). The soil is a sandy clay loam.

CAUDATA

Cryptobranchus alleganiensis alleganiensis Daudin.—An adult hellbender, 51 cm. in total length, was taken in a tributary of the Oconee River in Barrow County. It represents the southernmost record for the species and, in addition, the first record of its occurrence in the Altamaha River drainage system. Previously the hellbender was known in Georgia only from the Tennessee River drainage system. Accordingly it is possible that this individual was introduced.

Diemictylus viridescens viridescens Rafinesque.—The common newt occurs generally throughout the area. Adults are found in most bodies of standing water that contain floating and emergent vegetation. The terrestrial stage is difficult to find. Despite much collecting in apparently suitable habitats, only three efts have been taken. Then, too, no large larvae have been collected. The life history of this species in the Athens area is accordingly not clear at present. All specimens have distinct, black-bordered, bright red spots. No evidence of intergradation with *D. v. louisianensis* is apparent.

Ambystoma tigrinum tigrinum Green.—The eastern tiger salamander is known only from a single larva collected May 17, 1953, from a pond near Whitehall, Clarke County. It completed metamorphosis in the first week of July. I think that this burrowing species is more abundant than my collecting has indicated, but it obviously is not so common as *A. opacum*.
Ambystoma opacum Gravenhorst.—The

marbled salamander is very common. It is particularly abundant in the forested areas adjacent to the flood plains of rivers and large streams, where adults may be found under fallen trees throughout the year. Myriads of larvae are present in flood plain ponds during the winter and spring. Transformation takes place in the latter part of May and in early June.

Ambystoma maculatum Shaw.—The spotted salamander, like the tiger salamander, is also represented in the University of Georgia collection by a single juvenile specimen. It was found in a flood plain pond along a tributary of the Apalachee River in Oconee County on April 23, 1953. It was kept in captivity and did not transform until the middle of the following September. However, the spotted salamander is not so rare as my collecting has indicated, for there are several authenticated records of its breeding near Athens.

Desmognathus fuscus fuscus Rafinesque.—The northern dusky salamander, found along almost every stream, is more commonly encountered than any other salamander in the area. In general, the more rocks and logs near and in a stream, the larger the population of this salamander. Extensive deposits of sand and silt obviously reduce the size of the population. Several locally representative series have been taken. These show striking variation in pattern and intensity of pigmentation. The general dorsal color is brown or yellowish brown; however, a few bright chestnut-red specimens have been collected. Most individuals have a definite dorsal band with irregular margins, or else two dorsal rows of roundish light blotches, but occasionally there is no evident pattern. There is also much variation in the ventral markings. Most specimens are lightly pigmented, but some are darkly mottled and closely approximate the pattern of *D. f. auriculatus*.

Desmognathus quadramaculatus Holbrook.—The black-bellied salamander has been introduced by fishermen, who use this animal as live bait (Martof, 1953). Although found in some of the larger farm ponds, there is no evidence that it is successfully established.

Plethodon glutinosus glutinosus Green.—The slimy salamander is common under logs and stones in wooded sections. All specimens have large, irregularly shaped, white markings on the

sides of the body and several, widely scattered, tiny, white flecks on the back. Numerous small individuals, 30 to 40 mm. in total length, were taken in March, presumably the month when transformation occurs. Fifty adults averaged 147 mm. (range 105 to 157 mm.) in total length.

Hemidactylium scutatum Schlegel.—A single specimen of the eastern four-toed salamander, a female 75 mm. in total length, was collected on April 1, 1953, near Lexington, Oglethorpe County. It was under a small log in an oak-gum woods about 50 yards from a large creek. The soil under the log was a hard clay-loam and contained much moisture. There was no evidence of a nest. In Georgia the distribution of this species is very enigmatic. The only other place it has been found is near Augusta (Neill, 1951).

Gyrinophilus danielsi dunni Mittleman and Jopson.—The Carolina purple salamander has been taken at Athens, the southernmost locality for the species. Four specimens have been taken under large rocks and overhanging roots of trees along streams. These specimens range from 140 to 159 mm. in total length, average 151 mm. When two newly captured specimens were each confined in a small jar, each regurgitated a dusky salamander, apparently a major food item for *Gyrinophilus* in the Piedmont.

Pseudotriton montanus montanus Baird.—The eastern mud salamander inhabits the larger and muddier bodies of water. It is frequently found among fallen leaves which have settled in the quieter pools, especially in flood plain ponds. Individuals seem to be widely scattered, for in no place have more than a few been collected.

Pseudotriton ruber ruber Latreille.—The northern red salamander is found throughout the area, but it is not abundant. Larvae have been collected in the smaller and rockier streams, especially near springs. The adults are generally found under rocks and logs situated in or near streams or some distance away. This species is apparently more terrestrial than the eastern mud salamander. Although most specimens are clearly of the northern race, those from the southern half of the area have some of the characteristics of *P. r. vioscai*: white dots on the snout and sides of the head and dorsal spots arranged in an

approximate herringbone pattern. Bishop (1943) stated that *P. r. vioscai* is limited to the Coastal Plain but, obviously, it intergrades with *P. r. ruber* in the southern third of the Piedmont.

Eurycea bislineata cirrigera Green.—The southern two-lined salamander is common. It is especially abundant in the vicinity of springs and small streams. Females taken in January and February are greatly distended with eggs. Most egg laying takes place in late February and March. A group of 36 eggs found attached to the undersurface of a rock in a small running stream on February 22, 1952, developed into larvae which escaped from their egg capsules on March 3 and 4. The average diameter of the egg capsules was 6.4 mm. and the average total length of the newly hatched larvae was 11.1 mm. Eight transforming larvae, taken September 15, 1952, average 72.1 mm. in total length; range from 64 to 77 mm. Many individuals overwinter as larvae.

Eurycea longicaudata guttolineata Holbrook.—The southern long-tailed salamander is widely scattered in the Athens area. It is found under logs, stones and leaves in the vicinity of streams, especially the larger ones. A local series of about 30 specimens has been collected, but at no one time have more than a few been taken. Transforming individuals have been found from the middle of May to the end of August.

SALIENTIA

Bufo terrestris americanus Holbrook.—The American toad is uncommon. The only specimens taken were located in the breeding season in the latter half of February. By having a short and early breeding season, this species is distinctly isolated from *Bufo woodhousei fowleri*. Only three of the 14 specimens collected have dark dorsal spots; however, the nature of the cranial crests and dorsal warts is obviously that of *Bufo terrestris americanus*.

Bufo woodhousei fowleri Hinkley.—Fowler's toad is common. From March through November it can be collected in large numbers. The breeding season is long, extending from about mid-March to the first of July. Egg laying takes place in ponds, large and small, and in the quieter pools along the larger streams. Large series of specimens have been taken.

Acris gryllus crepitans Baird.—The cricket-frog is the most abundant frog in the area.

Breeding takes place in practically all quiet ponds but especially in those located in the flood plains of the larger streams. Males may be heard calling from the last of May until the first week or two of September. Transforming individuals have been taken from about mid-June to mid-September. All specimens have prominent anal tubercles and rather fully webbed feet.

Pseudacris nigrita feriarum Baird.—The eastern chorusfrog has a greatly variable dorsal pattern. The character of the markings on the sides of the body is more persistent than that of the back. In all except two of a group of 50 specimens the lateral markings consist of solid stripes extending from the tympanum to about two-thirds the distance to the groin. The most variable marking is the middorsal stripe; it is broken in 44 individuals. Variation in the dorsal pattern of the 50 frogs may be indicated as follows: striped, no stripes broken (2); striped, one stripe broken (9); striped, two to three stripes broken, several spots (10); equally striped and spotted (13); spotted, middorsal and dorsolateral rows discernible (10); spotted, middorsal and dorsolateral rows obscure (6). In snout-vent length, 20 males average 27.0 mm. (24.9 to 29.1); four females average 32.2 (31.4 to 33.1). The ratio of tibia length to snout-vent length for 20 specimens is 50.2 (approximately 49 to 52). The breeding season starts early in January and continues until the first or second week of April. However, the calls of a few widely scattered individuals were heard during warm, moist days of November and December.

Hyla crucifer crucifer Wied.—The spring peeper occurs throughout the area. It prefers to breed in the smaller and more-open field ponds and pools rather than in those of the flood plain; however, both are used. The first calls were heard in the second week of January; most vocalization occurred in the last half of February and the first half of March; a few individuals were heard calling as late as the first week of May. The above subspecific title was based on information in Wright and Wright (1949). Actually many individuals are more spotted on the venter and possess broader dorsal markings than do most specimens taken in the southernmost parts of Georgia, presumably near the center of the range of *H. c. bartramiana*.

Hyla versicolor versicolor LeConte.—Most

specimens of the common treefrog were captured while calling from the ground along the edges of small ponds and puddles. Many called while on vegetation a few feet from the water and one was about 12 feet up in a tree. The breeding season begins the last of April and reaches its height during the next month and a half. A few frogs were heard calling as late as the last half of August. A large series has been collected.

Rana catesbeiana Shaw.—The bullfrog occurs commonly throughout the area. It may be heard calling from late April through August and is well adapted to breeding in the many newly constructed farm ponds. I have seen seines actually jammed full of tadpoles which were of edible proportions. On the average the tails of the tadpoles constitute about 41 percent of their weight (average weight of tadpole is 22 grams), and when they are soaked overnight in vinegar and fried (undoubtedly there are other methods of preparation) they are a very appetizing food. Here I think we have a solution to the frog farming problem. Actually much is known about the endocrinology and breeding of frogs; many thousands of tadpoles can be grown in a single pond, they are easily harvested and prepared for cooking, and above all, they are surprisingly delicious, ranking even with frog legs. The rearing of tadpoles is very sound ecologically. They feed primarily on algae; thus a simple food chain is involved in which the ultimate "consumers" feed directly on the initial "producers."

Rana clamitans Latreille.—The greenfrog is moderately common, occurring chiefly along the larger pools of streams. For breeding, it seems to prefer the more densely vegetated flood-plain ponds to the open farm ponds. The first calls of the season are heard about the middle of April, the last about the end of August; the height of the breeding season occurs in May and the early part of June. The largest male collected has a snout-vent measurement of 86 mm.; the largest female, 87 mm.

Rana palustris LeConte.—Specimens from Oconee County represent the most southern records for the pickerel frog. Its characteristic call can be heard from mid-January through March. There are reports in the literature of individuals calling from in and under the water, but all that I found in the Athens area were on

the vegetated banks of large ponds and lakes. Only 11 specimens of this rather rare and sporadically distributed animal have been taken. They were all located by their calls.

Rana pipiens sphenoccephala Cope.—The southern meadow frog is the most common one of the larger species. The males begin to call early in January and may be heard through June. In contrast to *R. palustris*, these frogs call from out in the water. They call not only from the smaller ponds, but also from the same larger ponds and lakes where *R. palustris* was heard on the banks. Most breeding occurs during the rainy season in February and March. Transforming frogs have been collected in the latter half of May and throughout June.

Microhyla carolinensis carolinensis Holbrook.—The narrow-mouth toad is very secretive. It begins to call in the first part of May and can be heard until the last half of August. The major part of the breeding season occurs during and after the June rains. A series of 25 males averaged 27.6 mm. in their snout-vent measurement, with a range from 26.1 to 28.6 mm. The excrement of all specimens taken into the laboratory was made up entirely of the exoskeletal fragments of ants. The ponds used for breeding are sporadically located in the Athens area. It seems that only the ponds in certain areas are utilized even though many apparently favorable breeding sites are between them.

UNCONFIRMED REPORT

Scaphiopus holbrookii holbrookii Harlan.—Wright and Wright (1949) indicated that the spadefoot toad occurs throughout Georgia except for the Cumberland Plateau. At present there is no evidence that it occurs in the Athens area; in fact, I have not been able to locate it north of the Fall Line. Several auto trips were made to Athens from the southern part of the state at times when the spadefoot was calling; none was ever heard north of the Coastal Plain.

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Brassy Flecking in the Salamander *Plethodon c. cinereus*, and the Validity of *Plethodon huldæ*

WILLIAM B. MUCHMORE

IT is well known that some individuals of *Plethodon c. cinereus* Green have a well defined reddish dorsal stripe and dark sides and that others are uniformly dark dorsally and laterally. Also, some are variously intermediate between the striped and dark phases, and some are erythristic. References to these color variations are found in many accounts of the species, a good general description occurring in Bishop (1941). The present paper discusses a feature of the coloration of *P. c. cinereus* that apparently has never been recorded in the literature, but which has, nevertheless, figured to some extent in the taxonomy of other species of *Plethodon*.

While collecting *P. c. cinereus* in the Genesee River gorge at Rochester, New York, in the autumn of 1953, I was struck by the fact that the dark ones were conspicuously peppered with tiny light flecks. Microscopic examination in the laboratory revealed that this flecking was due to numerous individual iridophores distributed more or less evenly over the whole dorsum, upper sides, and upper surfaces of the legs. These small chromatophores, which show an iridescent golden or brassy color, are located just external to the melanophores which produce the ground color of the above mentioned areas. The iridophores usually are quite small (0.02-0.05 mm. in diameter) and relatively widely separated; occasionally those on the tail, and less often those on the head or lower back, are larger (0.1 mm.) and so close as to touch one another, giving the appearance of a reticulum. In an extreme instance of the latter situation the brassy coloration may occupy as much as one-half of the dorsal surface of the tail. These brassy iridophores are not to be

confused with the larger guanophores (0.1-0.2 mm.) that may also be found scattered over the dorsum and which were mentioned by Green (1818: 356) in the original description of the species, "back . . . sprinkled with small white dots."

Further observation reveals that the striped individuals, as well as the dark ones, show a conspicuous flecking of the darker parts of the dorsum, such as the head and the end of the tail. Indeed the intensity of flecking, that is, the size and number of iridophores, is often as great as that found in most of the dark specimens. Further, microscopic examination shows that iridophores are frequently present also over the dorsal stripe, though less readily observable because of the underlying erythrophores.

Surprisingly enough, search of the literature revealed no mention of such coloration in *P. cinereus*, although similar flecking has been recorded for related forms in western United States such as *Plethodon neomexicanus* Stebbins and Rierner and *P. vandykei idahoensis* Slater and Slipp (Stebbins, 1951). And, according to Grobman (1944), "the outstanding unifying characteristic of the Welleri Group [*P. richmondi* Netting and Mittleman, *P. nettingi* Green, *P. welleri* Walker, and *P. huldæ* Grobman] is the presence of dorsal greenish golden to brassy flecks which usually disappear in the preservative." Indeed, the most recently described species of the *welleri* group, *P. huldæ* (Grobman, 1949), is held to differ conspicuously from dark-phase *P. c. cinereus* only in the possession of such flecks. The flecked, dark-backed animals taken at Rochester conform closely to the description

given in *huldæ*.

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given by Pope (in Grobman, 1949) of living *P. huldae*.

Correspondence with a number of competent herpetologists discloses that flecking of the dorsum in *P. c. cinereus* is recognized as a fairly widespread color feature. It has been observed, according to my correspondence, in Massachusetts, New York, New Jersey (even at Princeton, the probable type locality of the species), Pennsylvania, Virginia, West Virginia, Ohio, and Michigan. I, myself, have seen living specimens, quite similar to the Rochester series, from Wyoming and Cattaraugus counties, New York; Ashtabula, Hamilton and Lorain counties, Ohio; Bucks County, Pennsylvania; and Rockbridge County, Virginia. Since there is this widespread distribution and since the flecking may be as intense on striped as on dark individuals, it is very unlikely that each of the observations represents a separate species of *Plethodon* or even a subspecies of *P. cinereus*. Most likely, then, the occurrence of golden or brassy chromatophores in greater or lesser numbers is a normal feature of the coloration of *P. c. cinereus*.

Absence from the literature of any mention of this coloration may have been due to one or another of the following reasons: (1) herpetologists in certain areas may have had under observation only unflecked or sparsely flecked individuals; (2) others may have studied only preserved material and so missed the flecking which fades rather quickly in standard preservatives; and (3) still others have noticed the flecks but have not reported the situation. In any event, the lack of accurate information in the literature about so common and widespread a form as *P. c. cinereus* has caused considerable confusion concerning the affinities of this and related forms.

Since the flecked forms found at Rochester are fairly representative of *P. c. cinereus* and since there is such close resemblance between the dark-backed members of this series and *P. huldae*, it is my opinion (which correspondence shows to be shared by others) that the two forms are equivalent, i.e., *Plethodon huldae* Grobman is a synonym of *Plethodon c. cinereus* (Green). The considerations set forth in the following paragraphs have contributed to the formation of this opinion.

Grobman (1949: 139) pointed out that "*huldae* comes to resemble lead-backed *cinereus*

after being in preservative." Thus, the two forms apparently cannot be separated on the basis of preserved specimens.

Grobman seemingly thought that the presence of brassy flecks in living *P. huldae* is a sufficient criterion for distinguishing it from *P. c. cinereus*. However, flecking is also common in living *P. c. cinereus*, and many, if not most, dark-phase *P. c. cinereus* conform in the living condition to the description of living *P. huldae* given by Pope (in Grobman, 1949: 138).

I have examined several living specimens (striped, dark and intermediate phases) taken by Richard L. Hoffman on May 22, 1954, near Milepost 35, Blue Ridge Parkway in north-eastern Rockbridge County, Virginia, an area well within the range of *P. huldae* as described by Grobman (1949). These animals have been compared directly with living specimens of *P. c. cinereus* from Bucks County, Pennsylvania (near the probable type locality), from Lorain County, Ohio, and from the Rochester area. No differences can be detected which are not within the range of variation seen among individual populations. The dark animals taken by Hoffman were not so heavily flecked as some and more heavily flecked than others of the dark specimens of *P. c. cinereus* from New York and Ohio. Particularly significant here is the observation that the striped *P. c. cinereus* from the Blue Ridge are distinctly, though not heavily, flecked; that is, both the dark and the striped forms share this color characteristic. Thus it cannot be maintained that *P. huldae* differs from even the local *P. c. cinereus* in the possession of dorsal flecks.

Through the courtesy of Dr. Grobman I have been able to examine a series of 108 dark and striped animals taken by him and W. Auffenberg in the summer of 1951. These were all collected within an hour's time at Big Meadow, Skyline Drive, Virginia, not far from the type locality. They have been studied to determine whether morphological differences exist between the dark and striped forms.

COSTAL GROOVES.—The costal grooves were counted following Grobman's method (1949: 137). Both sides of each animal were counted but no asymmetries were found. The distribution is as follows:

	18	19	20	21
Dark.....	3	9	2	0
Striped.....	9	72	12	1

The agreement in this sample is somewhat better than that in the sample studied by Grobman (1949: 137), in which costal grooves of *P. c. cinereus* averaged slightly fewer than those of *P. huldae*. The difference in costal groove counts between dark and striped forms is not significant ($\chi^2 = 1.725$).

VENTRAL COLORATION.—The dark specimens tend to be somewhat darker ventrally than the striped ones. This same trend is noticeable among dark and striped specimens from Rochester and from Lorain County, Ohio.

TEETH.—The teeth of all these specimens conform in general to the description of the situation in *P. c. cinereus* (Bishop, 1943: 234). No differences can be detected between dark and striped forms with respect to number and placement of the vomerine teeth or distribution of the parasphenoid teeth.

SIZE.—Since the tails of most specimens have been broken and variously regenerated, it is fruitless to attempt a size comparison of the animals on the basis of the total length; on the other hand, the body length (tip of snout to posterior edge of vent) is not subject to such accidental variation. In the series under consideration the dark and striped specimens that may reasonably be considered adult compare as follows (measurements in mm.):

	No.	Range	Mean	σ
Dark...	11	36-49	43.8 \pm 1.15	3.81 \pm 0.81
Striped..	85	33-51	41.5 \pm 0.48	4.40 \pm 0.34

Grobman published no measurements of *P. huldae*, not even those of the holotype. However, he suspected (*op. cit.*: 138) that they are intermediate in size between *P. richmondi* and *P. nettingi*, which places them within the range of *P. c. cinereus*. The above figures show that they are, indeed, quite similar in size to the striped *P. c. cinereus* taken with them. The slight differences that are apparent may be found in populations from other areas. For example, a similar size comparison of a Rochester series taken on April 24, 1954, follows:

	No.	Range	Mean	σ
Dark...	18	37-48	41.9 \pm 0.64	2.73 \pm 0.46
Striped..	88	36-51	42.2 \pm 0.36	3.38 \pm 0.25

On the basis of the foregoing, it appears that

no differences can be detected between dark and striped plethodons of the Blue Ridge that warrant their separation as different forms. My opinion is that the salamanders which have been described as *Plethodon huldae* are in reality the dark-backed segment of the local population of *Plethodon c. cinereus*.

Since *P. c. cinereus* possesses brassy flecks on the dorsum and since *P. huldae* can no longer be considered valid, it is certainly desirable that the concept of a *welleri* group of *Plethodon* distinct from a *cinereus* group be abandoned. The "unifying characteristic of the Welleri Group—the presence of dorsal greenish golden to brassy flecks" (Grobman 1949: 311) can not be used to distinguish these forms from *P. cinereus*. It is probable that *P. nettingi*, *P. richmondi*, and *P. welleri* are all rather closely related to *P. cinereus*.

I wish to express my gratitude to the following for providing valuable information and comment: Drs. J. W. Burger, E. R. Dunn, G. Fankhauser, N. B. Green, A. B. Grobman, M. G. Netting, F. H. Test, and A. H. Wright; Messrs. M. B. Mittleman and N. D. Richmond. Special thanks are due to Messrs. Richard L. Hoffman and Donald M. Green for collecting and sending to me living salamanders from Virginia and Ohio, respectively.

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Herpetological Records from the Gómez Farías Region of Southwestern Tamaulipas, México

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AN investigation of the vertebrates inhabiting part of the Sierra Madre Oriental and adjacent tropical lowlands of southwestern Tamaulipas near the northern limit of several important tropical animal habitats has yielded considerable information of ecological and biogeographic interest. The following account lists only reptiles and amphibians that have not been recorded previously from Tamaulipas, with annotations for those of special significance. A faunal analysis treating the ecological and historical implications drawn from observed distribution patterns is in preparation.

The area under consideration is a quadrangle of about 4,000 square km., bounded by the towns of Llera, Jaumave, Ocampo and El Limon on the northeast, northwest, southwest, and southeast, respectively, and includes the Huastecan village of Gómez Farías. In this region the Sierra Madre rises sharply from the gulf coastal plain to an elevation of 2,400 m. within 15 km. southwest of Gómez Farías. Here the higher part of the Sierra, with various types of cool humid forests, is isolated from similar environments to the north by the Río Guayalejo canyon, and southward by the Antiguo Morelos syncline. To the west a series of dry ridges and valleys give way to the very arid Mexican Plateau.

The present study is preceded by an ornithological project originated by Sutton (Sutton and Burleigh, 1939; Sutton and Pettingill, 1942) and continued by several individuals. Apparently most of the early biologists, including Nelson and Goldman, never investigated southwestern Tamaulipas, and I am aware only of the activities of Edward Palmer who collected plants at Gómez Farías in 1907. Thus, not until construction of the Laredo-Mexico City highway in the early nineteen-thirties did the tropical lowland forests in this area attract serious study. Until 1948, the higher parts of the Sierra Madre west of Gómez Farías were unknown biotically. In that year a field party including Ernest P. Edwards, Roger P. Hurd, and myself collected in both cloud forest at Rancho del Cielo (1,100 m.),

7 km. northwest of Gómez Farías, and in arid pine-oak parkland at La Joya de Salas (1,500 m.). Subsequent study in these montane forests has yielded many distributional records of both floristic and faunistic interest (Sharp *et al.*, 1950; Hernandez, *et al.*, 1951; Robins and Heed, 1951; Harrell (in manuscript); Hooper, 1953; Goodwin, 1954) and of the 39 reptiles and amphibians representing new Tamaulipan records, 25 are from this upland area.

During the present study over 2,500 herpetological specimens of 95 species were collected in the Gómez Farías region. Of these, 39, or about 41 percent of the total fauna, represent new state records, as follows: Salamanders—*Chiropterotriton multidentata*, *C. chondrostega*, *Pseudoeurycea belli*, *P. cephalica*, *P. sp.* Frogs—*Eleutherodactylus latrans*, *E. hidalgoensis*, *Syrhophus latodactylus*, *S. cystignathoides*, *S. sp. (smithi group)*, *Hyla eximia*, *H. miotympanum*. Snakes—*Adelphicos quadrivirgatus*, *Amastidium sapperi*, *Coniophanes frangivirgatus*, *Elaphe triaspis*, *Geophis semiannulatus*, *Imantodes cenchoa*, *Rhadinaea crassa*, *Scaphiodontophis cyclurus*, *Tantilla rubra*, *Tropidodipsas sartori*, *Storeria hidalgoensis*, *Thamnophis cyrtopsis*, *T. mendax*, *Bothrops atrox*, *Crotalus durissus*, *C. lepidus*. Lizards—*Sceloporus jarrovi*, *S. torquatus*, *S. parvus*, *S. scalaris*, *Laelmanctus serratus*, *Leiolopisma sp.*, *Abronia taeniata*, *Gerrhonotus liocephalus*, *Xenosaurus newmanorum*, *Lepidophyma flavimaculata*. Turtles—*Kinosternon integrum*.

Many species in this list are known both from the south (San Luis Potosí) and north (Nuevo Leon) or otherwise so close to the Gómez Farías region that their presence in Tamaulipas is scarcely remarkable. Revisionary accounts of others of greater interest have appeared (*Crotalus lepidus* and *C. durissus*, Klauber, 1952; *Elaphe*, Dowling, 1951; *Laelmanctus*, Peters, 1948; *Thamnophis mendax*, Walker, 1955; and *Thamnophis cyrtopsis*, Milstead, 1953), while reports on *Chiropterotriton*, *Pseudoeurycea*, and *Lepidophyma* are in manuscript. In addition to these the following eight species of apparent tropical origin deserve

TABLE I

FREQUENCY OF SUPRALABIAL COUNTS IN *Xenosaurus grandis* FROM CUATLAPAN, VERACRUZ AND *X. newmanorum* FROM XILITLA, SAN LUIS POTOSÍ (DATA FROM TAYLOR, 1949), AND FROM THE GÓMEZ FARÍAS REGION, TAMAULIPAS

Number of supralabials	<i>X. grandis</i>	<i>X. newmanorum</i>	
	Veracruz	San Luis Potosí	Tamaulipas
18	1	..	..
19	..	..	..
20	4	..	..
21	5	..	..
22	11	..	..
23	5	..	1
24	6	1	..
25	..	2	..
26	..	1	1
27	..	3	2
28	..	..	..
29	..	5	..

further comment as noteworthy records of poorly known forms. Unless mentioned otherwise, all specimens are now deposited in the Museum of Zoology, University of Michigan (UMMZ).

Xenosaurus newmanorum.—At the northern limit of its range, *Xenosaurus* occupies at least two radically different habitats. Two males collected by William Lidicker and John Mackiewicz about 4 km. southeast of La Joya de Salas and 30 km. south-southeast of Jaumave in July, 1951, came from dry oak-pine woods (montane low forest) on the western side of the Sierra Madre Oriental at 1,700 m. elevation. In December, 1952, Rezneat Darnell received two additional specimens, both females, from villagers along the Río Sabinas at La Unión (Tulane 15473). This latter locality, 150 m. in elevation, is roughly 10 km. north of Gómez Farías in an area of sub-humid tropical forest (tall tropical deciduous forest). *Leiopisma* is one of the few other reptiles from the Gómez Farías region that occupies both these areas. Tamaulipan specimens, compared with 33 adults of *X. grandis* from Cuautlapan, Veracruz, appear to differ from that species essentially as does the type series of *newmanorum* (see Taylor, 1949). Among many diagnostic features, three seem worthy of further comment.

(1) Supralabials.—*X. newmanorum* has a higher average number, 26.8 (combined counts), than *grandis*, with 22 (Table I).

(2) Color pattern.—A dorsal body pattern of six to seven light brown or pale gray brown bands is usually conspicuous in *grandis*, except in very large individuals. The anterior two bands are V-shaped, the first always incomplete and extending from the lateral temporal region above the tympanum dorsad toward the top of the neck. In Tamaulipan *newmanorum* this body pattern is poorly developed and the anterior V-shaped band is scarcely visible.

(3) Body tubercles.—This character is not readily expressed in quantitative terms, but it is diagnostic for the specimens at hand; those of *newmanorum* are smaller and more closely spaced. At midbody the following approximation of tubercle numbers in a row between, but not including, the lateral fringes was as follows: *newmanorum*, 19, 21, 21, 22; *grandis*, 12, 13, 13, 14, 15, 15, 16, 16.

Although numerous minor morphological differences presently serve to distinguish these two species, their distribution and that of their southern relative, *X. rackhami*, suggest a common allopatric relationship.

Abronia taeniata.—Twenty-six specimens, including four unborn, taken over a 6-year period in humid montane forest near Gómez Farías, trace the range of *Abronia* north from Cerro Conejo in San Luis Potosí (Taylor, 1953). In current taxonomic practice, *A. graminea* and *A. taeniata* are treated as subspecies (Tihen, 1949, 1954; Smith and Taylor, 1950). Tihen (1954) based his evidence for intergradation on four juveniles from La Joya, Veracruz. Although he pointed out that they fall within the range of variation of *graminea*, he noted that they approach and overlap with *taeniata* in three features, as follows: (1) high number of dorsal scale rows, two of the specimens with 29 and one with 30 rows; (2) six nuchal scales; and (3) more distinct transverse brown bands than is usual for *graminea*. I have seen two adult males collected by J. E. Mosimann, G. B. Rabb, and T. M. Uzzell from this same locality, which also approach *taeniata* in dorsal scale rows (29 in both) and overlap in number of nuchal rows (six). Nonetheless they are strikingly different from Tamaulipan *taeniata* in possessing keeled dorsal scales, and,

in life, indicating additional differences between I have bromel Other typical Smith

In a featur pared *graminea* Veracr Puebl have suboc eye, a count scales (6), a scale cept count and separ scales Tihen appe the b to th slight keele

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in life, a brilliant light green color without indication of dark transverse body bands. In addition, they both have 14 ventral scale rows between the lateral folds, a higher number than I have found in *taeniata*. Both came from bromeliads in pines growing in a lava field. Other specimens from La Joya, also considered typical *graminea*, are mentioned by Smith, Smith, and Werler (1952).

In an effort to evaluate some of the key features used to distinguish *taeniata*, I compared 26 Tamaulipan specimens with 25 *graminea* from Acultzingo, two from La Joya, Veracruz, and three from Puente Colorado, Puebla. All members of the Tamaulipan series have two post mentals, two anterior temporals, subocular scales separating labials from the eye, and six nuchal scale rows. In *graminea*, counts of the minimum number of nuchal scales were as follows: four (17 specimens), five (6), and six (5). Maximum number of ventral scale rows at midbody is 12 in all *taeniata* except one with 13; in *graminea* the following counts are represented: 12 (4 specimens), 13 (7) and 14 (7). A more reliable scale character separating these forms is number of dorsal scales (Table II), counted as described by Tihen (1949). A final diagnostic feature is the appearance of the large body scales. In *taeniata* the body scales are flat and smooth in contrast to those of *graminea* which are rounded and slightly rugose on the head and distinctly keeled on the body.

Living *Abronia* are often highly colored; many individuals of *taeniata* have orange, or orange and black bellies and, as color appears important in distinguishing *graminea* from *taeniata*, the following information from the field catalogue of Charles F. Walker is presented. Of two males collected near Rancho del Cielo, the ground color of one (UMMZ 102982) was a pale gray, almost white, with seven large jet black body bands and a sooty head spot. On the ventral side a bright orange-yellow prevailed, most brilliant in the preanal and lower belly region, although scales on the throat and chest area had gray bases. The under side of the legs was a rich butter-yellow while the under side of the tail as far back as the black, regenerated portion was also yellow, suffused with much gray laterally. The second (UMMZ 102983) was similar, but the black on

the head, and on most of the tail was jet like that of the body. The ventral surface was even brighter orange-yellow although yellow tipped scales did not extend as far dorsally and the median five or six scale rows lacked yellow entirely. In both of these specimens the iris was a pale bluish gray, almost like the ground color. Of six other specimens for which I have color notes, only two, one a juvenile, lacked an orange or yellow-orange abdomen. Development of melanophores on the abdomen is more variable; some preserved specimens are unpigmented below while others are almost completely black. Throughout the Tamaulipan series, jet black body bands are usually separated by light gray or bluish white cross bars, although in three specimens they are expanded, forming a continuous jet black mid-dorsal stripe. The pattern of four prehatchlings is brighter, but otherwise quite similar to that of the adults.

Thus it appears that color and pattern will distinguish specimens of *taeniata* and *graminea* as effectively as any feature of scutellation. The adult of *A. graminea* is a uniform bright green with a pale yellow throat and lacks distinct body blotches; *taeniata* is pale gray or gray-bluish with a harlequin pattern of black bands or polygons and generally an orange-yellow venter. The body bands in *taeniata* represent retention of the juvenile pattern which is suppressed in adult *graminea*. Admittedly, their known distribution is allopatric, but in view of the marked morphological differences noted above, and in the absence of definite

TABLE II
DORSAL SCALES IN TWO SPECIES OF *Abronia*

Number of scales	<i>A. graminea</i>	<i>A. taeniata</i>
25	1	..
26	3	..
27	11	..
28	8	..
29	7	..
30	..	2
31	..	10
32	..	9
33	..	3
34	..	1
35	..	..
36	..	1

intergrades, it seems desirable to retain a binomial taxonomic arrangement.

Abronia taeniata is a sluggish, very slow-moving lizard, relying on its powerful jaws for defense. Walker found two adult males, their jaws interlocked, lying quietly along a forest path in tall cloud forest near Rancho del Cielo. Others captured by hand would bite stubbornly, not releasing their hold until pried loose. Although the genus is considered arboreal (Tihen, 1949) and *graminea* is usually found in bromeliads, one juvenile, supposedly caught in a tree by a lumberman, is the only one of the 11 specimens for which I have field data that was not discovered on top of leaf litter, or on rocks on the ground. Both Walker and I have noted that *Abronia* has a strong prehensile tail; however, an individual with a regenerated tail used it less effectively. One hung from my finger by looping its tail back on itself, then sought to reach my wrist by lashing about vigorously and swinging up to the horizontal.

Like many lizards inhabiting damp, rather cool forest, *A. taeniata* (in Tamaulipas) is viviparous. Of 19 adults, only two were females; the oviducts of one collected on March 10 contained 11 undeveloped eggs, each about 9 mm. in diameter, but the other, collected on June 2, contained four young ready to be born. In total length one of these measured 68 mm.; the smallest posthatching juvenile, taken August 1, measured 82 mm. Thus it appears that the young are born at the beginning of the rainy season, which usually starts between the middle of May and the middle of June.

Throughout its distribution in México and Central America, *Abronia* inhabits cool, mesic,

montane environments, either cloud forest or humid pine-oak forest. In the Gómez Farías region it ranges through both these habitats on the eastern side of the Sierra Madre between 1,100 and 2,000 m. Of five species of lizards collected in the Rancho del Cielo cloud forest, only *Abronia* and possibly *Lepidophyma* can be considered true forest dwellers, living under the canopy away from clearings or other openings.

Adelphicos quadrivirgatus newmanorum.—Seven complete specimens and parts of four others, collected with the help of a road-building crew 13 km. north of Ocampo at 1,000 m. on April 20–22, 1953, extend the known range of this species north from Xilitla, San Luis Potosí. In addition to *Adelphicos*, we caught eight individuals of *Tantilla rubra* and a single *Bothrops atrox* in a day and a half. All were taken under flat, limestone rocks in an area of thick tropical vines and shrubs, with scattered trees reaching a height of 20 m. The wealth of dense low growth, including mala mujer, suggested fire regeneration. Semi-arid, low montane tropical forest, probably disturbed, roughly describes this area.

This series resembles *A. q. quadrivirgatus* as follows: scale count 15–15–15; supralabials 7; infralabials 6; temporals 1–1; enlarged anterior chin shields come in contact with the labial border; a dark median line of pigment runs posteriorly from the anus; two postoculars (fused to form a single postocular in two specimens). Ventral scale counts are somewhat higher than those known for *A. q. quadrivirgatus* (Table III).

In life the ground color is rose red, and the head is almost black. The ventral surface varies from coral red to light pink; however, in the largest specimen the venter was cream yellow and the dorsum yellow-brown, entirely lacking any suggestion of rose or pink. Five of seven female specimens contained eggs, the largest having four.

In describing *newmanorum* as a new species of *Adelphicos* from Xilitla, S.L.P., Taylor (1950) had two complete specimens, one of which he considered *quadrivirgatus*. The other differed as follows: (1) complete suppression of body lines except for a faint median band; (2) a longer frontal; (3) top of head more reddish brown; and (4) labials of lesser height.

Variation in development of lines on the body

TABLE III
SCALE COUNTS AND MEASUREMENTS OF
Adelphicos g. newmanorum

UMMZ No.	Sex	Ventrals	Caudals	Total length
109717	♀	141	44	402
109709	♀	148	42	323
109712	♀	152	42	340
109710	♀	155	41	345
109713	♀	150	28+	345+
109708	♀	147	43	267
109714	♂	142	50	284
109715	♂	...	47	...
109716	♂	...	48	...

is apparent in the Tamaulipan series. While eight resemble Taylor's figure of *newmanorum* in lacking lateral and dorsolateral lines, three others show distinct, though broken, dorsolateral lines, intermediate in this respect between the two Xilitlan specimens. That intrapopulation pattern variation is extensive is shown by a series of *A. q. sargi* from a one-acre plot at Finca La Paz, Guatemala. Despite the dark ground color, five stripes, occasionally seven, are usually discernible in this form; however, among 117 which could be classified, I noted five different pattern reduction types represented by 13 specimens. In these, either the lateral, dorsolateral, or median lines were lost, and at least three specimens (L. C. Stuart Field Nos. 6470, 6503 and 6565) match *newmanorum* in loss of stripes. Thus absence of lateral and dorsolateral stripes seems a feature which may be expected to occur with varying frequencies in single populations of *Adelphicos*.

In the Tamaulipan specimens, the frontal is longer than the snout-frontal distance, and the average number of ventral and subcaudal scales is higher than in *A. q. quadrivirgatus* reported by Smith (1942a). This can be appreciated as an absolute difference if the two counts are added together, obtaining for females of *newmanorum*, 196, 194, 190, 190, 188 (type), and 185; of *quadrivirgatus*, 178, 170, 168, and 167. One male *newmanorum* has a total count of 192, while two *quadrivirgatus* have 180 and 173. Lacking comparative material of *A. q. quadrivirgatus*, I have not examined the Tamaulipan series with respect to Taylor's features (2), (3), and (4) (see above); however, these appear as relatively minor characters when not reinforced by (1) as an absolute feature. Thus I conceive of variation among Mexican *quadrivirgatus* in which, from south to north, unstriped individuals increase in frequency; the frontal increases in length relative to that of the snout; and both ventral and subcaudal counts increase. In this interpretation I view the differences between the two Xilitlan specimens as examples of variation among *Adelphicos* in that area, and consider them with the Tamaulipan series as subspecies of *A. quadrivirgatus*.

Coniophanes frangivirgatus.—An adult male, UMMZ 104048, was included in a collection from Pano Ayuctle, 7 km. north-northeast of Gómez Farías, assembled in 1950 by Reznat

M. Darnell, Jr. I am indebted to James A. Peters for comparing it with the type and supplying the following information concerning variation: ventrals 161, last divided; anal divided; caudals 54+; 8 upper labials, 4 and 5 in eye; lower labials 9, 4 in contact with anterior chin shields; preoculars 3; postoculars 2-1 (5th upper labial on right fused with lower postocular); temporals 1/2; nasal divided; dorsal scales 23-25-19; anal ridges present; total length (455 mm. body + 109 mm. tail) 564 mm., part of tail missing. Color as in holotype except not so suffused with dark below lateral line, and stippling on ventrals at the first scale row is very light. In the stomach were remains of *Hypopachus*.

In maximum number of dorsal scale rows (25), and number of upper labials (8), this individual resembles *C. piceivittis* more closely than the type does; however, the light nape spot remains a diagnostic feature. As suggested by Peters (1950), a subspecific relationship with *piceivittis* is likely.

Geophis semiannulatus.—Nothing more revealing than Smith's account of the type (1941) and brief mention of an Hidalgo record (1942c) has appeared concerning this species. Thus the present series of 12 specimens from southwestern Tamaulipas is of interest as (1) the first series collected; (2) a range extension of 320 km. northwards from Guerrero, Hidalgo; and (3) throwing further suspicion on the source of the type, allegedly from Colima. Except in lower number of subcaudal scutes in females, I find no outstanding differences between Tamaulipan individuals and those reported by Smith. Little variation is apparent within the present series. All have a single pre- and supraocular; the supralabials are 6, the 3rd and 4th entering the eye, the 5th the largest; temporals are either 1+1 or 1+2; scale rows are 17 throughout and all are perfectly smooth; ventral scale counts for males are 165, 167, 171; for females, 178, 178, 180, 181, 182, 182, 183, 184, and 184; subcaudals (in same sequence) of males are 43, 42, and 45; of females, 31, 33, 31, 32, 31, 33, 32, 32, and 34. Except for a single specimen with 50, there are 33 to 39 body bands, which extend at least to the ends of the ventrals and in seven reach the midline. Total length of the largest specimen, a female with four eggs in the oviduct, is 405 mm.

In life adults exhibit dusky reddish or rose-

pink body bands between black cross bands; however, three juveniles (170 mm. in length) lacked the rosy cast entirely and were described in Walker's field notes as dull bone-white with black cross bands.

Nine *Geophis* came from under stones and logs in the Rancho del Cielo cloud forest between 1,100 and 1,400 m.; three others were collected under logs about 4 km. west of Rancho del Cielo in humid pine-oak forest at 1,800 m. Three specimens from Guerrero, Hidalgo (Smith, *loc. cit.*), also were taken in humid montane forest, although at higher elevation (2,600 m.). Such cool humid forests presently occur only as scattered environmental islands in the Hidalgo-San Luis Potosí-Tamaulipas segment of the Sierra Madre Oriental.

Scaphiodontophis cyclurus.—A dead female (UMMZ 106511), found dead on the road in Gómez Farías, extends the known range of this genus northward 400 km. from central Veracruz. Scutellation features are as follows: ventrals 147; caudals 75+; scale rows on body, 17; preoculars 1-2; postoculars 2-2; supralabials 9-9; infralabials 9-9; post-temporals 1+1+1, 1+2+1. Body bands before preservation were red, yellow, and black; the stomach contained a skink tail, apparently *Leiolopisma*.

As four of the seven members of the *annulatus* species group to which this specimen belongs were represented only by the types at the time of the last revision (Taylor and Smith, 1943), virtually nothing is known about individual variation. The possibility that certain features, such as development of body bands, currently used to recognize species of *Scaphiodontophis*, actually represent intraspecific variation can not be rejected. Except for a completely banded tail and low number of white body bands (nine), the Tamaulipan individual differs from the type description of *cyclurus* and resembles the specimen Taylor and Smith (*loc. cit.*) called *nothus* as follows: primary temporals do not touch 6th labial; white cross bars are wider medially ($4\frac{1}{2}$ scale rows) than laterally ($1\frac{1}{2}$ scale rows); widest black band, six scales in width, lies above the anus; lateral margin of ventrals and edge of first scale row stippled with gray on body, forming distinct spots on the subcaudals; and first black band following nuchal color is $2\frac{1}{2}$ scales wide. In addition this individual differs from both

nothus and *cyclurus* in greater length of the posterior, black head band which extends over the first four rows of body scales. Since the characters of the present specimen raise doubt as to the validity of *nothus* and *cyclurus*, and as the relationship of these to *zeteki* has not been clarified, I use the name *cyclurus* with reservation.

Amastridium sapperi.—Two females of this rare snake, caught by W. F. Harrison at Rancho del Cielo 7 km. northwest of Gómez Farías (1,100 m.), corroborate Smith's remarkable Nuevo Leon record (1944). Of 172 snakes representing 14 species collected in Tamaulipas cloud forest, this is the least known and last added to the fauna. Both were caught in the daytime, one inside a recently constructed board house and the other on carpet grass in the Rancho del Cielo clearing. Three previous Mexican records of *Amastridium* from the Pacific slope of Chiapas are all from the foothills rainforest (coffee belt). Two *Eleutherodactylus* were found in the oesophagus of one of these.

The similarity between Chiapan and northeastern Mexican specimens deserves further comment. Smith (1943, 1944) has published scutellation data on two of the Chiapan specimens, which he could not distinguish from his Nuevo Leon example. I have recorded data on two others (UMMZ 88304, Escuintla, Chiapas; H. Wagner No. 1310, Chiapas) which also resemble Nuevo Leon and Tamaulipan individuals. In the specimens I examined (and in the others also, presumably) the scale rows number 17 throughout the body; a single preocular is followed by 2 postoculars; supra- and infralabials number 7 and 9, respectively, with the third and fourth supralabials enter-

TABLE IV
SCUTELLATION AND MEASUREMENTS (IN MM.) OF
FOUR FEMALES OF *Amastridium sapperi*
FROM TAMAULIPAS AND CHIAPAS

Character	Catalogue number			
	109702	109701	88304	HW 1310
Ventrals....	168	170	166	165
Caudals....	79	82	58+	31+
Total length....	724	225	496+	382+
Tail length....	180	55	100+	47+
Locality....	Tamps.	Tamps.	Chis.	Chis.

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ing the orbit; temporals number 1+2. Other scutellation data for the four specimens not seen by Smith are summarized elsewhere (Table IV).

In color pattern, however, these four are not identical. Although considerable ontogenetic color change, mainly a diminution in pigment intensity and a masking of pattern markings, is apparent in the Tamaulipan specimens, both may be distinguished from the Chiapan individuals by their much lighter, pale gray, instead of dull black, bellies. Except for a light head and nape (yellow or red in life?), UMMZ 109701 is almost black dorsally, with the belly pale gray by contrast. The peculiar, characteristic white spots on every 2nd to 5th scale of the 5th and 6th rows are less conspicuous than in those from Chiapas. In UMMZ 109702 the body is uniform gray above with the top of the head and nape only slightly paler than the body. A head pattern is scarcely recognizable, as are the spots of the 5th scale row. Shortly after preservation the head was rusty brown and the anterior part of the body olive gray.

In addition to much darker ventral scales, the Chiapan females have conspicuously keeled supra-anal scales, a feature barely distinguishable in the Tamaulipan individuals. Nonetheless, despite these relatively minor differences, these snakes, collected 1,100 km. apart, are remarkably similar.

Imantodes cenchoa leucomelas.—This form is one of the many members of the tropical deciduous forest fauna that appear to find their northern limit in the Gómez Farías region. Central Veracruz is the nearest locality from

which the genus *Imantodes* was previously known. Two of three specimens brought to me at Rancho Pano Ayuctle in 1953 came from a palm-thatch hut; a third was captured near Gómez Farías. There are no outstanding differences in scutellation between these (Table V) and other Mexican specimens reported by Smith (1942b).

DISCUSSION

It is apparent that most of the species added to the Tamaulipan fauna in the present study represent forms of tropical origin which find their northern range limit in the Gómez Farías region. Evidence from birds (Sutton and Pettingill, 1942; Eaton and Edwards, 1948) and mammals (Baker, 1951; Hooper, 1953; Goodwin, 1954) indicates a similar pattern with many species, genera, and even families of wide tropical distribution reaching their latitudinal limits on the Atlantic slope of southern Tamaulipas. The climatic, vegetational, and other factors responsible for this tropical element in the Tamaulipan fauna require a more complete evaluation than I can offer at present. It may suffice to point out that certain vegetation types including cloud forest and tropical deciduous forest, both influential in determining the faunal aspect, are very near their northern limit in the Gómez Farías region.

The general distribution of tropical habitats and biota in eastern México suggests a step-wise gradient in which various forest types encounter limiting environmental conditions, notably diminishing precipitation from southern Veracruz to southern Texas. The Xilitla region of southeastern San Luis Potosí (Lowery and Newman, 1951; Davis, 1952; Taylor, 1949, 1950, 1953) and the Gómez Farías region of southwestern Tamaulipas represent successive steps in this gradient where sizable segments of the tropical American biota terminate.

ACKNOWLEDGMENTS

I have enjoyed many collecting days with the following individuals all of whom contributed specimens listed in this report: B. E. Harrell, W. F. Harrison, W. B. Heed, E. P. Edwards, R. P. Hurd, W. Z. Lidicker, J. Mackeiwicz, M. Martin, J. A. Mosiman, J. A. Peters, C. R. Robins, G. M. Sutton, T. M. Uzzell, and C. F. Walker. R. M. Darnell and C. M. Bogert sup-

TABLE V
CHARACTERISTICS OF *Imantodes* FROM THE
GÓMEZ FARIAS REGION

Character	UMMZ number		
	109700	109699	109698
Sex.....	♀	♀	♀
Ventrals.....	236	237	241
Caudals.....	149	144	146
Dorsals.....	17-17-17	17-17-17	19-19-19
Labials			
(upper).....	8	8	8/9
Labials			
(lower).....	10	10	10
Number of			
body bands..	28	31	33

plied data on specimens taken during visits in this area. For thoughtful comments on the manuscript I am indebted to C. M. Fugler, G. B. Rabb, and C. F. Walker. Support for field work during 1953 was provided by the National Science Foundation; earlier trips were financed in part by the Museum of Zoology, University of Michigan and by George M. Sutton. Collecting permits were provided by the Dirección General Forestal y de Caza in Mexico City. A final word of gratitude is due both Everts Storms of Rancho Pano Ayuctle and W. Francis Harrison of Rancho del Cielo whose invaluable assistance and warm hospitality not only made field work in the Gómez Farías region feasible, but extremely pleasant.

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Observations on the Ecology and Behavior of the Pacific Treefrog, *Hyla regilla*

BAYARD H. BRATTSTROM AND JAMES W. WARREN

THE Pacific treefrog, *Hyla regilla*, is one of the most abundant amphibians in western North America. It is found from British Columbia to the tip of Baja California and from the Pacific Ocean east to western Montana, Idaho, Utah, and Nevada. It occurs from sea level to an elevation of 11,600 feet. Little is known, however, about the general natural history of this small treefrog. Early in the year of 1953, while working on the general distribution of some southern Californian amphibians and reptiles, data were also obtained on the ecology and behavior of this treefrog.

This research has been supported by a grant from the Richfield Oil Corporation and has been done under the guidance of Dr. Raymond B. Cowles. The writers wish to thank him and Dr. Clark P. Read for their criticisms and suggestions.

STUDY AREA

Unless otherwise mentioned, the data presented herein apply to treefrogs collected or observed in the various streams, ponds, or lakes along, and usually the result of, the San Andreas Fault from the town of Gorman (elevation 4,000 feet) to the town of Palmdale (elevation 2,000 feet), Los Angeles County, California (Fig. 1). Trips were made along the highway from Palmdale to Gorman about every 2 weeks from January 1 to July 25, 1953 and occasionally after that.

TEMPERATURE DATA

The temperature of the lakes, streams, and ponds, as well as the air and soil was taken and the temperature and behavior of the hylas noted. All temperatures were taken with a Schultheis thermometer.

Water temperature was taken at 1-inch and 6-inch depths; that of the air was taken at 1 inch above the water and at 3 to 5 feet above both land and water. Though the data, resulting in more than 500 temperature readings, were taken at many places, only the data for one area, the ponds at Gorman, are reproduced here (Table I). Areas varied in their *Hyla*

fauna according to the size and temperature of the habitat. For instance, small streams and ponds were occupied early in the season since they were heated sufficiently by the January and February sun and did not cool off greatly at night. The larger lakes were usually not utilized for singing or breeding because they did not become sufficiently warm until after the breeding season. Small, cold (3°-8° C.) streams from underground springs were not occupied by the hylas, though they were found in warm ponds or lakes within 1,000 feet.

In medium sized lakes the activity of the hylas was variable. Hidden Lake, for example, is supplied by an underground spring that seeps through the grass and dirt down a small hill; at the edge of the lake there are many grass-covered 4-to-10-inch-deep depressions made by the hooves of grazing cattle. If during a cold night, the small seeps or depressions about the lake fringe area freeze, the frogs concentrate in the lake proper. If the lake becomes too warm (20° C. or above) by mid-afternoon, the adults go to small pools or seeps where the water is cooler (average, 15° C.). When these small depressions cool off too much, the frogs return to the lake proper which held the heat for some time during the night.

When the frogs were singing, they would often be in water of 10° to 12° C. with just their heads above the surface in air with temperatures of 5° to 10° C. When the air was warmer than the water the frogs would sing from sticks, grass, etc., in the air. If air temperatures became too hot and the hylas too warm, they would jump into the cool water for a short time as a means of cooling off.

ARTIFICIAL LAKE TWO MILES SOUTH OF PALMDALE.—This is a body of water approximately 100 by 500 yards. It is used for fishing and is stocked with bass and bluegill. It is bordered by cat-tails and a Creosote-Juniper-Joshua Tree association. Coots are usually present. Water temperatures varied from 9.4° to 15° C. No amphibian eggs or larvae were ever seen in or near the lake, but on February

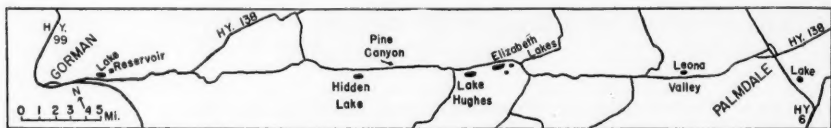


Fig. 1. Map of road between Gorman and Palmdale, Los Angeles County, California, showing places mentioned in the text.

2, at 5:40 PM, *Hyla regilla* was heard on the shore's edge and on July 18, a few hyla and many juvenile *Bufo boreas halophilus* were seen.

LEONA VALLEY.—In Leona Valley there is a pool approximately 20 by 60 feet and from 3 to 12 inches deep, and a shallow (1–2 inches deep) stream without vegetation. There were no hylas in the stream until March 7; on that date several adults were heard singing at 11:45 AM. In the grass-bottomed pond *Hyla* was not observed until February 2, when many were singing in it (water 11.5°, air over water 6° C.). On February 13, at 11:30 AM no hylas were observed in the pond (water temperature, 16.8° C.) but upon lifting up some dead tumbleweeds which had blown into the pond, a *Hyla* was uncovered sitting in the water (at 6.3° C.). After March 7 no adult amphibians were observed in the pond. On April 11, at 10:30 AM an aggregation of about 180 *Hyla* tadpoles was observed concentrated in a circle about 2 feet in diameter. A description of the aggregation will be given below.

FISHING POND EAST OF ELIZABETH LAKE.—This is a small (100 by 150 yards) artificial pond stocked with fish for use by members of a private club. Water temperatures varied from 9.7° to 13° C. No amphibians were seen or heard in the pond except for one *Hyla* heard on January 23 at 3:12 PM. The vegetation about the pond consists of a few planted trees, *Quercus agrifolia*, and grass at the water's edge.

PONDS AND STREAM SOUTH OF ELIZABETH LAKE.—In a grassy meadow and field, about one-half mile south of Elizabeth Lake (and up the hill from it) there are several small ponds, one large one (50 by 150 yards), and a small stream. The vegetation consists of several large poplars (*Populus fremontii*), grass and cat-tails. The temperature of a small pond 4 by 20 feet and 15 inches deep varied from 9.9° to 21.4° C. When the ponds were too warm, the

TABLE I
OBSERVATIONS ON *Hyla regilla* IN PONDS AT
GORMAN, LOS ANGELES COUNTY,
CALIFORNIA, 1953

Date	Time	Temperature of water, °C.		Temperature of air over water, °C.		Remarks
		6 inches	1 inch	1 inch	3–5 feet	
1/3	1430	10.5 –12	...	9.0	15.0	Adults singing; no eggs; snow $\frac{3}{4}$ mile away.
1/11	1635	12.5	...	9.8	...	Many adults singing; freshly laid eggs.
1/24	1400	15.5	17.0	16.0	...	Adults singing; eggs.
2/2	2155	6.0	...	6.5	...	No <i>Hyla</i> singing in this pond; eggs.
2/2	2156	10.0	9.8	6.5	...	<i>Hyla</i> singing in this pond; eggs.
2/13	1505	13.0	14.0	9.0	7.5	Eggs; larvae; adults singing.
3/7	1710	14.2	...	17.5	...	Eggs; larvae; adults singing.
4/11	1525	10.8	13.0	...	12.0	Many tadpoles.
4/27	1250	15.0	13.0	...	12.0	Tadpoles $\frac{3}{4}$ to $1\frac{1}{4}$; no adults seen.
5/17	1400	15.0	17.2	21.0	17.0	Tadpoles in all pools; some with hind legs; fresh eggs in pools 15° or less.
6/20	0950	14.0	14.0	15.0	15.5	Adults seen; no eggs; larvae 10 mm. and up.

hylas were often heard or found in the grass about 20 feet from the water.

PINE CANYON.—The temperature of a small stream from an underground spring in Pine

Canyon varied from 5.0° to 18.6° C. It never contained *Hyla*, probably because it lacked vegetation.

HIDDEN LAKE.—This small lake (about 300 by 400 yards) was formed by the San Andreas fault. It is surrounded on the east and south by dense chaparral and on the west by a grass meadow. On the north the lake is bordered by *Artemisia tridentata*. There are cat-tails in the lake. On the west side there are many small depressions, made by cattle feet, that are filled with water and surrounded by grass. Water temperatures of the lake varied from 8° to 20.8° C. Hylas were heard on the first visit, January 11, and on every subsequent one.

LAKE, 2 MILES EAST OF GORMAN.—A large lake (about 500 by 1,000 yards) located 2 miles east of Gorman had temperatures that varied, from 8.2° to 12.0° C. It never contained hylas but they were present in streams leading into it (water temperature usually 10° to 15° C.).

RESERVOIR, 2 MILES EAST OF GORMAN.—A concrete reservoir or tank in a small valley about 400 yards northeast of the above lake is located on the east side of the valley 10 feet above a cold stream. The reservoir is about 20 feet square and 10 feet deep with vertical sides. The water depth varied from 12 to 35 inches and supported a growth of *Spirogyra* and water-cress (*Rorippa*). The reservoir also contained the branches of a small bush, and several boards. Water came into the reservoir through a small pipe located about 5 feet above the bottom. The outlet of this pipe was surrounded by water cress. Most of the observations of behavior mentioned below were made at this station. By lying on our stomachs we could observe the hylas without disturbing them.

Water temperature varied from 9.4° to 13° C. These low temperatures may be due to the fact that part of the reservoir was always shaded by the vertical walls.

GORMAN.—At Gorman, at an elevation of 4,000 feet, there are some marshy pools and a stream between a side road and the main highway (U. S. Hwy. No. 99). These ponds vary in size from one square foot to 25 or 30 square feet. The surrounding area consists of grass, *Salix* and cat-tails. Water temperatures, taken in a small pond 4 feet by one foot and 12 inches deep, varied from 6° to 22° C. (Table I).

SUMMARY OF TEMPERATURE DATA.—The following is a summary of the various body temperatures and associated behavior in *Hyla regilla* in response to various environmental temperatures. They are based on over 500 temperature records.

When air or soil temperatures get above 10° C. and *Hyla regilla* can warm up enough, they will emerge from hibernation or retreats and will go to water. If the water temperature is 8° C. or above, they will remain there. When in the water they do not sing until the water or the air temperature (and body temperature) reaches to 9.8° to 10.0° C. At temperatures of 9.8° to 9.9° C. they can barely vocalize and the sound is a weak croak. That they do not (or can not) sing below 9.8° C. was suspected, as we noted their behavior in the various lakes. We were convinced, however, when on February 3, at 7:15 PM we observed *Hyla* in the Richfield Oil Company's South Cuyama Oil Field in Cuyama Valley, Santa Barbara County. In a small canyon about 10 feet deep in an open meadow, hylas were found in a small stream 2 feet wide and about 12 inches deep. The air temperature in the canyon was 5° C. and the water temperatures varied from 9.7° to 10.2° C. We observed that male hylas in water of 9.7° or 9.8° C. did not call or sing, but in water (in small coves or pools of the stream) of 10° (body temperature of hylas, 9.9° C.) and 10.2° (body temperature, 10.2°) they did call.

Hyla regilla will sing or be active in the water or air until it gets too hot (20° C.). Above 20° C. they will seldom, if ever, sing. At this temperature they will go to cooler ponds or to shade in the grass.

Eggs are not laid until water temperatures at the site of egg-laying are 12° C. In water temperatures above 15° C. no eggs will be laid; instead, the frogs go, by random wandering, to other ponds (if available) where the water is cooler. The eggs, after laying, can survive temperatures of -5° to -7° C. for 2 hours and as high as 34° C., though the later stages of development (Neurula and tail-bud stages) can withstand 38° C. for 2 hours and survive (Schlechtman and Olson, 1941). Of course the rate of embryological development increases with temperature up to the point of lethality. Tadpoles in continuously warm pools will de-

velop and metamorphose more quickly than those in cool pools. Tadpoles apparently can stand low temperatures (0° to 2° C.) as well as high temperatures of 33° C. but they seem to prefer temperatures of 19° – 20° C.

The optimum (preferred) body temperature appears to be about 15° C., though active individuals (hopping about on grass, leaves, etc.) varied from 14.3° to 22.2° C. (Body temperatures of hylas were taken either cloacally or by placing the thermometer between the appressed femur and body. There was no difference in temperature between the two methods on the same individuals.) Hylas were, of course, found in the water singing, with body temperatures as low as 9.9° and 10.2° C.¹ The lethal temperature for adults appears to be 38.1° C. (38° and 38.2° C. in two experiments). Schechtman and Olson (1941) found that tail-fin and pre-hatch stages of larvae were killed if kept at 39° C. for 2 hours while the lethal temperature of blastula, gastrula, and neurula appears to be 35.5° , 37° , and 38° C., respectively.

Logier (1952) found that *Pseudacris n. triseriata* did not sing in water temperatures below 47° F. (8.5° C.). We do not know how much acclimation occurs with respect to body temperature, lethal temperature, etc. It is probable that the temperature data given above (temperatures for singing, egg-laying, etc.) will vary several degrees with latitude and altitude (Jameson, MS).

COLOR CHANGE

Any person who has collected or observed *Hyla regilla* in nature is impressed by the color variation. A study of the variation in *H. regilla* was given by Test (1898) who described five "styles of color." Though there are many variations, the two main colors of *Hyla regilla* are green and brown. Both of these color phases are found with or without black markings. These black markings are variable in size, shape, and number. Both of the colors occur in a light and a dark phase. The dark phase usually occurs only in the presence of spots, whereas light phases are found in individuals with or without spots. Occasionally individuals with red, or with brown backs and green sides are found, but these make up only about five

percent of the population. In all the color phases, however, the characteristic black stripe along the side of the head is always present.

The majority of the workers on western amphibians remark on the amount of color change possible in this amphibian. For instance, Klauber (1934) says, "It has the capacity to change its color considerably and may be bright green, gray or brown in almost any shade." Stebbins (1951) stated, "... capable of marked color change (from dark brown to bright green);..."

To determine what factors caused the color change, a series of experiments were performed. In none of the experiments described below did a green *Hyla regilla* change to brown, or vice versa. As will be seen below, we could make a *Hyla* get light or dark (i.e. light or dark green and light or dark brown) and gain or lose its spots, but never could we produce a change in their basic colors. Under high temperatures and intensive illumination, both green and brown hylas appear yellow due to the extreme "contraction" of the melanophores. A person seeing one yellow *Hyla* turn brown after cooling, and another green, might mistake this for a brown *Hyla* changing to green, or vice versa (also see Noble, 1931). Apparently in all the previous reports (Klauber, 1934; Stebbins, 1951) hylas were generally assumed to be changing color. Perhaps individuals of mixed colors, in jars, moved about so that it appeared that each individual changed color. It is also possible that change from green to brown, or brown to green, does take place in other parts of its range, but most of the evidence is to the contrary (Jameson, MS). All the specimens used in the various experiments described below came from Gorman, Los Angeles County, though observations were made on some from other areas and no color changes from green to brown, or brown to green, were observed.

It is possible that the basic color, green or brown, is a genetic character (which seems to be the case, as indicated by experiments by Jameson, MS), and the lightening and darkening, or gaining and losing of spots is environmentally controlled. No counts have been made on the number of individuals of each color in each pool, but general observations have shown that green and brown phases occur in about-equal numbers. Test (1898) could find no geo-

¹ John Cunningham and Don Mullally (personal communication) have recently found *Hyla regilla* active with body temperatures of 1.5° C.

graphic describe patterns Department of California observed female observed in natural colors.

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graphic correlation with the five styles of color described by him, though in some areas certain patterns tend to predominate. Mr. Arlan Smith, Department of Zoology, University of California, Los Angeles, reported to us that he observed a light green male and a light brown female in amplexus in the laboratory. We have observed matings between different color phases in nature about as often as between the same colors.

To determine if there is a selection of a background color to match the basic color of the frog, a glass aquarium 3 feet long, 1 foot wide, and 15 inches high was filled with 4 inches of water. Half of the tank was surrounded on the top, bottom and sides by apple-green paper, and half by light brown paper. In the aquarium a piece of glass 5 inches high was placed across the aquarium to separate green algae and pondweed on the side with the green paper, and brown sticks and leaves on the side surrounded by brown paper. Hence the frogs had access to all parts of the aquarium. Four brown-spotted and four green-spotted adults were placed in the aquarium and their positions noted at least once a day for 3 weeks. At each observation the distribution of the green- and brown-colored hylas in the tank was at random. It is possible that this was due to the small size of the aquarium, but we also observed in nature that there was no color selection. In the small concrete reservoir, 2 miles east of Gorman, mentioned above, about half of the reservoir was covered with *Spirogyra*. This green alga was predominantly on one side of the reservoir. The remainder of the pond was covered with brown sticks and boards. Green and brown frogs were randomly distributed in the pond; both phases were observed sitting for long periods of time on top of the green algae (partly or entirely out of the water) or on the brown sticks. It is possible that the variation in color and color pattern is sufficient so that in normal activity, most of the individuals of each population will be in areas where by chance they will be protectively colored. Though an individual may be caught by an enemy on a different colored background, the variation itself is of survival value to the population and the species. It is our opinion that *Hyla regilla* is composed of such panmixic, variable, interchanging populations that no subspeciation has yet occurred.

In the following experiments all animals used were from Gorman, Los Angeles County. Usually from 6 to 40 animals were used in each experiment with controls used in all. The frogs were kept in the experimental situations for several hours and occasionally for several days.

Some hylas have small bumps on their back associated with color change (light to dark, with or without spots) but it appears to us that this is associated with high temperatures or desiccation.

SEGREGATION.—In each experiment green and brown (spotted or unspotted, light or dark) frogs were kept separate or, if not, they were marked, usually by toe clipping. No individuals were observed to change from green to brown or vice versa. As mentioned above a small percentage of the population may be mixed green and brown (*i.e.* brown on back and green on sides) in these individuals the color of the respective areas did not change.

LIGHT AND DARK.—In a lighted aquarium most of the frogs (green or brown) became lighter and in a darkened aquarium (covered by black paper) they became darker. Exposure to long periods of light or dark does not affect the basic color of green or brown as it does in *Hyla versicolor* (Edgren, 1953). Water temperatures in both tanks, as with all temperatures except those dealing with temperature, was approximately the same (25.0° and 25.8° C).

EXCITED AND NON-EXCITED.—With one tank as a control, frogs in another were disturbed continuously for about 20 minutes by stirring the water in the tank by hand and not letting any individual stand still or crawl on the glass for more than 5 seconds. No color change was noted from green to brown or vice versa or from spots to no spots or vice versa. One brown-spotted individual became lighter but kept its spots. Temperature of the water 24.2° C.; control, 23° C.

COLOR OF THE BACKGROUND.—Eleven marked, mixed-colored *Hyla* were put in an aquarium with apple-green paper all around it and eleven were placed in an aquarium similarly enveloped with light brown paper. In one hour's time no color change was noted. The following day the *Hyla* were segregated by color, light-dark, spots-no spots, into separate glass dishes 4 inches deep and 12 inches in diameter. These dishes were covered with tan,

or black paper; the control dishes were not covered. Frogs in the tan-covered dish grew lighter and one lost its spots; most of the individuals in the black-covered jar grew darker. Those in the control dishes remained unchanged. If hylas are placed in an aquarium with an even colored background and in one with a variegated (*i.e.* cross-hatched) background, they lose their spots in the first situation and gain spots in the second. (The writers wish to thank Mr. Arlan Smith of our department for some of these data which were obtained as part of a project in the course in herpetology.)

TEXTURE OF SUBSTRATE.—It has been shown by Hargitt (1912), Biedermann (1926) and others that the texture of the substrate effects color change in some species of *Hyla*. Three experiments were performed in which *Hyla regilla* was placed on smooth and rough-textured substrata, but no color change was noted. Controls and experimental animals were placed in transparent glass dishes 12 inches in diameter. In one dish a 4 × 4 × 4-inch, ¼-inch-mesh basket was placed, the bottom of another was covered with pebbles, and that of another sand. The latter two were covered by wire screen to prevent the frogs from reaching the smooth glass. In two of the controls sand or pebbles were placed under the glass dish so that the visual clue would be the same as the experimentals but the texture smooth. No color changes were noted in any of the situations. Again, the temperature was essentially the same in all containers (24.8° to 25.2° C.).

BEHAVIOR AND SEX.—Allen (1950) reported that *Hyla cinerea* and *H. crucifer* change color while calling. No such color change was noted in *H. regilla*. The various colors appear to be equally distributed in the two sexes of *Hyla regilla*.

TEMPERATURE.—In general, in brown hylas medium high temperatures (32° C.) cause darkening and loss of spots; very high temperatures (above 32° C.) cause lightening and loss of spots; very cold (below 14° C.) temperatures cause darkening and gain of spots. In green hylas, medium high temperatures (32° C.) cause loss of spots and lightening of color, while cold (14° C. and lower) causes gain of spots, but the body color remains light. At medium temperatures green hylas are dark with spots.

SUMMARY OF COLOR CHANGE.—*Hyla regilla* does not change from green to brown or vice versa. The color changes noted are caused by one or more factors. This hyla becomes spotted on variegated backgrounds and loses spots on even-colored ones. Individuals lose spots at high temperatures and gain them at low ones. They become dark in dark areas or on dark backgrounds and light on light-colored ones. Brown hylas become dark at low and medium high temperatures and light at very high temperatures. Green hylas become light at both high and low temperatures and dark at medium temperatures. Intensive illumination and/or heat cause both green and brown hylas to become yellow; this is due to the extreme melanophore contraction, and these individuals return to their basic color when cooled.

In nature (and occasionally in laboratory experiments) the general pattern presented above is sometimes obscured because individuals may respond to one condition more readily than to another, or respond to one set of conditions and then move to another (from a light-colored, warm leaf to a dark-colored, variegated leaf). If these individuals are observed by the investigator before a new response is completed, erroneous conclusions may be formed.

BEHAVIOR

"SINGING."—Storer (1925) stated, "If a person walks out into a marsh where hylas are chorusing the notes quickly cease. . . . If the intruder remains quiet the hylas will usually resume after a few minutes, one individual beginning in a rather hesitating manner, then being joined by others one by one until the full chorus is under way once more." Some simple experiments at the reservoir, 2 miles east of Gorman, convinced us that the frogs detected us, and presumably its enemies, by our movements. We hid behind the wall of the reservoir on January 11 at 2:00 PM and were quiet until the chorus was under way. We then shouted and yelled, but there was no diminution in the volume of the chorus. Then, still hidden, we threw small stones, sticks, etc., into the reservoir with no decrease in singing. Pounding on the concrete wall in order to set up vibrations in the water yielded negative results as well, but as soon as we raised our heads above the

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rim the frogs stopped singing at once. We stood still, fully exposed to the view of the frogs and after a few minutes they began to sing again. Still in their view, we repeated the above experiments with noise, vibrations, and stones (with movements of our hands hidden) with the same negative result. However, if we moved our heads even a few inches, the singing would stop. We repeated these experiments at this and other localities, at different times of the day and night with the same results: the frogs did not stop singing unless the observers moved.

The main function of the singing of male *Hyla regilla* appears to be to attract females already within the pond. On January 11 at 2:00 PM we observed a female swim directly toward a male that had just commenced to sing. Amplexis resulted. Females (caught later to determine sex) swimming toward singing males in response to his singing were observed many times. Hence, it appears that the singing of the male helps in localizing the mating site, or perhaps more correctly attracts the female to the male. If the female could distinguish between the calls of several species, this would aid in species recognition in a pond containing many calling species. We are not convinced that the singing functions to attract females to the pond, but rather that its function may be for localization within the pond. It is probable that hylas reach ponds in the Spring by random searching or by some hydrotaxis.

SEX DISCRIMINATION.—As mentioned above, when a female hyla approaches a singing male, the latter usually stops singing and commences to mate. Should, however, a male happen to swim past a singing male, the singing male will often attempt to mate with it. Presumably an oncoming frog acts as a releaser and denotes to the singing male that it is a female (Cf. sticklebacks, Tinbergen, 1951). When amplexis between males occurs, the lower of the pair, usually the swimming male, begins to croak and inflate its vocal sacs. As soon as this is done, the male on top will usually immediately release his hold. The croak and/or the vocal sacs serve as a releaser in sex discrimination. We observed this many times on January 11 and on other days and in other areas. Similar types of sex discrimination have been recorded in other species of anurans (Noble, 1931; Noble and Aronson, 1942; Aronson and Noble, 1945;

Stebbins, 1951). It was noted on March 8 at 3:30 PM at the reservoir 2 miles east of Gorman that occasionally the top member of a pair of amplexing males would not release its hold when the lower one croaked, but would begin to scratch the abdomen and vocal sacs of the lower. This action suggests some aggressiveness, but as it is not associated with any definite area, territoriality is probably not involved.

SPATIAL LOCALIZATION.—Martof (1953) suggested that a "primitive territoriality" in eastern *Rana clamitans* is indicated by spatial localization. We do not think that his conclusions are completely justified by the facts as presented. If the term territory is to have any significance, it should be restricted to Noble's (1931) definition of "Any defended area." We believe that the data presented by Martof and our observations on *Hyla regilla* suggest a home range rather than any defended territory.

That spatial localization is present in *Hyla regilla* was indicated on certain occasions. When individuals of a peculiar coloration were disturbed or forced into the water, they would return after a few minutes to within a few inches of their original position. We interpret this as a home range, spatial localization, or local learning of an area, but not as a "primitive territory."

INTERSPECIFIC RELATIONSHIPS.—As far as we have been able to determine there is no competition between other anurans whose distribution is sympatric with *Hyla regilla*, with the possible exception of *Hyla arenicolor*. In those streams containing *Hyla arenicolor*, *H. regilla* is either absent or seems to be less abundant. *H. regilla* has a lower temperature preference and range for normal activity (8.0° to 22.0°; mean 16.2° C.) than does *H. arenicolor* (15.8° to 26.2°; mean 20.9° C.). It is possible that this temperature preference, plus (or is the cause of) the later breeding of *arenicolor* in southern California than *regilla*, allows these two forms to occur together in the same stream but not in competition due to differences in time of activity.

We have observed *Hyla regilla* singing in pools with calling *Bufo boreas halophilus* and *Scaphiopus h. hammondi* with the different species apparently taking no notice of each other. We have also observed them singing

with groups of *Rana catesbeiana*, but never closer to them than about 4 feet.

SEX RATIO.—In any one pond the number of females changes throughout the day. In the early morning almost all the frogs are males; by early afternoon a few females enter the pond. The number of females increases throughout the evening as more females come to the pond.

TADPOLE AGGREGATION.—Bragg (1945, 1946, 1948) and Carpenter (1955) have recorded and discussed aggregations in anuran tadpoles. As mentioned above, we observed an aggregation of *Hyla regilla* tadpoles in the pond in Leona Valley, Los Angeles County on April 11 at 10:30 AM. The pond at this date was from 3 to 6 inches deep and most of the bottom was covered with grass. Water temperature varied from 9.7° C. in the shade to 19° C. in the sun. The air temperature over the water was 10.2° C. One hundred and fifty to 180 tadpoles averaging 25 mm. in total length were aggregated in a circle about 2 feet in diameter. Occasionally a few individuals would leave the aggregation and swim about. They never swam more than 7 feet away from the center of the aggregation and would always return to the group after a few minutes. The water was 3 inches deep where the tadpoles aggregated and most of them were on or within a half-inch of the bottom. The water temperature above the center of the aggregation was 16.5° C. (one-half inch below the surface), and 19.0° C. at or within a half-inch of the bottom (and within the center of the tadpoles). The bottom temperature was 19° C. for about a five-foot radius from the center of the aggregation. The edges of the pond had water temperatures of 9.7° to 17° C.

Many of the tadpoles in the aggregation were in contact with each other and no cannibalism was noted. At least two-thirds of the tadpoles were oriented with their heads to the northwest. If radiant heat was an additional factor in causing the aggregation, this alignment of the tadpoles provided the maximum dorsal area of each individual to be exposed to the early morning sun which was directly to the southeast, the direction toward which most of the tails pointed. It is also possible that the mass of tadpoles would absorb more heat in the early morning than would single individuals, and though cannibalism occurs at this stage in nature and in the laboratory (Bragg, *supra cit.*),

this "social" aggregation might be advantageous in regard to body temperature.

A similar aggregation in this species was reported to the writer by Mr. William McFarland at Lake Hughes, Los Angeles County at 3:00 PM on May 13, 1953, in water 5 inches deep.

NATURAL HISTORY

FOOD AND FEEDING.—Needham (1924) reported on the stomach contents of 18 specimens of *Hyla regilla*. In 14 individuals from Gorman we found coccinellid, carabid, curculionid and gyrinid beetles, teridipediid midges, tabanid flies, mesoveliid hemipterans, cicadellid leafhoppers, as well as occasional unidentifiable beetle larvae, Hymenoptera, and Diptera. Needham's report supports our findings and the observation that *Hyla regilla* feeds predominantly above water. We have observed hylas crawling up in bushes or sticks in ponds to about 2 feet above the surface and there eat insects. These frogs often sit on floating *Spirogyra* and feed on insects crawling or alighting on the mass. Since *Spirogyra* is usually in the sun, the frogs often become too warm or dry. They then push down into the algal mass until they are almost completely covered by water. After a few minutes they again appear on top of the algae. Thick *Spirogyra* is quite an obstacle to the swimming frogs; many were seen struggling through it, especially those that came from underneath. At the reservoir 2 miles east of Gorman, the hylas would often congregate in the leaves of the water cress growing about the 2-inch supply pipe. The hylas sit in the shade near the base of the leaves of the water cress, but come out momentarily to feed on the occasional insects that alight.

SEASONAL ACTIVITY.—The seasonal activity of *Hyla regilla* seems to vary locally with temperature and the availability of water. In general, choruses in southern California are heard from November to July. Though occasional individuals are active in other parts of the year, the majority go into hibernation or hiding. At higher elevations and latitudes breeding is later in the season (Livezey, 1953; Stebbins, 1951; Storer, 1925). Storer reported hiding places such as piles of debris, burrows of meadow mice and other terrestrial mammals,

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crevices in boulders, artificial drains, basements of buildings, etc. In southern California, at least, the frogs must seek hiding places where they will not desiccate during the hot and dry months of July to October. In general, our observations support those of Storer (*op. cit.*). We have even found 40 adult hylas in the cranial and nasal cavities of a horse skull lying 3 feet from a stream.

On January 11 on the south-facing, rolling, grassy hills about 500 to 1,000 yards north and about 200 feet above the lake 2 miles east of Gorman, we heard hylas calling all about us. After searching for some time, we discovered males coming out of small (one inch in diameter) holes in the ground. They would sing a few notes and then retreat down the holes. Of some 20 holes found, we excavated 5 and found that they were consistently alike. The holes went down at about a 45° angle throughout the depth which was about 20 inches. Some holes contained from one to five frogs and, as many times as not, a *Uta stansburiana* was present. Occasionally the holes were empty and occasionally only a *Uta* was present. Hylas were observed in these holes again on January 24, but after that we never found them again, nor did we hear them calling from the hills. It is probable that hylas occupy similar holes in other areas, but thick vegetation may prevent one from noticing them. Whether *Hyla* or *Uta* digs the hole is unknown. The hole is just large enough in diameter for each, and since the soil was soft humus it would probably not be too big a task for either one.

On both dates the temperature of the air in the holes varied from 14° to 15° C., and soil temperatures varied from 10.5° to 14.5° C. Outside the holes air and soil temperatures varied from 16.5° to 18.2° and 14° to 15° C., respectively. Body temperatures varied from 19° for those just outside the burrow to 14° C. for those back in the hole. The testes of a male caught on January 24 in the hole were smaller than those taken from Gorman, 2 miles away, on the same day. The gonads of the females from the holes were generally small, and none of them had yet ovulated.

ENEMIES.—In southern California the enemies of *Hyla regilla*, other than man, seem to be gartersnakes (*Thamnophis*), egrets, herons, and such nocturnal animals that frequent

pools as raccoons, skunks, and opossums (Storer, 1925).

ALBINISM.—We wish to record here what appears to be the first record of an albino *Hyla regilla*. A metamorphosing albino *Hyla regilla* tadpole was brought to us at the University by Miss Barbara Sundberg who found it in a pool of the stream in Topanga Canyon, Los Angeles County. She found it along with several others, one of which she brought to us on another date. Many normal individuals were in the same pool which was about one mile from the mouth of the stream. In the laboratory, the first albino died just as the tail was beginning to be absorbed. The second specimen successfully completed metamorphosis but died within 2 weeks.

HYBRIDIZATION.—In many parts of southern California the distributions of *Hyla arenicolor* and *H. regilla* are sympatric. As mentioned above, where they occur in the same stream, *H. arenicolor* seems to be the more abundant. We have observed only one individual that appears to be a hybrid between these two species. This specimen (UCLA 6158) was taken on May 9, 1953 at the lowest grove of palms, Borego Palm Canyon, San Diego County. It is similar to *H. regilla* in color, except that it is mottled more than any *H. regilla* that we have ever seen. It approaches the granite coloration of most *H. arenicolor*. The skin is tuberculate as in *H. arenicolor* and the shape of the webbing of the feet (Salt and Stebbins, 1948) resembles that of *H. regilla*. The characteristic black bar through the eye and face of *H. regilla* is present only as a mottled outline. Though *H. arenicolor* was abundant, *H. regilla* was not observed in the canyon on this date, though it is known to occur higher up in the same creek. The presence of this probable hybrid does not mean that the species are invalid, but that on rare occasions *H. regilla* and *H. arenicolor* probably do hybridize in nature.

PROTECTION.—In addition to the advantages of the variation and changes in color, two activities that might be interpreted as protective behavior have been noted. When *H. regilla* is tossed or accidentally falls into water, it usually swims away, but if it should alight upside down, it will fold its legs along its sides and remain afloat in that position. We do not know the function of this behavior. It is possible that

it is a symptom of nervous shock or disturbed equilibrium.

In nature, if flushed on land, these hylas will usually jump into the water, if it is near. They will make several jumps if necessary to reach water, even if the intruder is between them and the water.

REARING.—Through the courtesy of Arlan Smith, we would like to present here some suggestions on raising tadpoles through metamorphosis. Larvae are placed in large bowls of water containing about one inch of sand and mud taken from the same stream that the larvae were taken from. If this mud is not put in with the tadpoles, they will eventually develop a haemorrhagic condition in the gut and die. Apparently mud aids in the digestion of the plant material which these larvae normally eat. For food the young larvae are provided with green algae. As metamorphosis begins, blocks of wood are placed in the bowls. When many tadpoles are seen about these blocks of wood, they are then changed to a larger aquarium. This consists of a 5- or 10-gallon tank with a sand or gravel bottom. One end of the tank is elevated about 2 inches by placing a block of wood under one end and about 2 inches of water is placed in the other end providing both an aquatic and a moist area. A thin cloth or screen cover is placed over the aquarium at this time to prevent metamorphosed frogs from crawling out. Since the food habits change during metamorphosis (Munz, 1920; Wright and Wright, 1949), the larvae are supplied with adult fruit flies (*Drosophila*). We use, if available, vestigial-wing mutants of *Drosophila* because they are easily caught by the young hylas. *Drosophila* can also be fed to adult hylas in the laboratory. An egg shell broken into several parts is also usually provided for the larvae. The small bit of albumin sticking to the shell is eaten by them. Only a small amount of water is necessary during metamorphosis, as the larvae are changing to air breathers.

SUMMARY

Observations on the ecology and behavior of the treefrog, *Hyla regilla*, made in the spring of 1953 in Los Angeles County, California are presented. Temperature appears to have a strong effect on its habits and behavior. *Hyla*

regilla can not be made experimentally to change from green to brown or vice versa, though lightening and darkening, and gaining and losing spots, appear to be environmentally controlled and can be experimentally performed in the laboratory.

Singing by the male of *Hyla regilla* acts as an attraction to the female in the local confines of a pond. Sex discrimination is accomplished by voice and inflation of vocal sacs. Male aggressiveness and spatial localization appear to be present, though territoriality is not. *Hyla regilla* perceives its enemies by their movements. Tadpole aggregations, enemies, hybridization, albinism, and probable protective devices are described. Notes on feeding, seasonal activity, and suggestions for rearing tadpoles are presented.

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DEPARTMENT OF ZOOLOGY, UNIVERSITY OF CALIFORNIA, LOS ANGELES 24, CALIFORNIA.

Upper Lethal Temperatures in the Salamander *Taricha torosa* as a Function of Acclimation

WILLIAM N. MCFARLAND

IN recent years a topic of extreme interest to experimental zoologists is that of acclimation of animals with respect to their environmental temperature. It has been shown in many invertebrates and fishes that the past thermal history of a given subject has a marked effect on its physiologic patterns (Prosser, *et al.*, 1950). Such phenomena as oxygen consumption are so adjusted that animals living at a lower temperature when compared to those living at a higher one show a relative increase in the rate of metabolism when compared at the same temperature (Wells, 1935; Scholander, *et al.*, 1953). It also has been demonstrated that fishes acclimated to cold water are less tolerant to higher temperatures than those acclimated to warm water (Hathaway, 1927; Fry, 1947; Brett, 1944). That such a phenomenon is characteristic of most aquatic poikilotherms is now well established (Bělehrádek, 1935; Prosser, *et al.*, 1950). The effect of temperature acclimation on amphibians has been studied but little; in fact in the entire class little is known about lethal temperature limits.

Davenport and Castel (1895) working on tadpoles of *Bufo terrestris* Bonnaterra were able to demonstrate differences in the upper lethal temperatures depending upon the temperature of acclimation. They showed that groups raised at 15° and 25° C. had average

upper lethal temperatures of 40.3° and 43.5°, respectively. The differential between the two groups was lost when readapted to the other temperature. However, this loss was not rapid, the upper lethal temperature of a 25° group being 41.5° after 17 days reacclimation at 15° C. Hathaway (1927) working with tadpoles of *Bufo terrestris americanus* Le Conte was able to show the same phenomenon, *i.e.*, the lower the acclimation temperature the lower the upper lethal temperature.

Mellanby (1940) has shown low temperature acclimation to exist in *Rana temporaria* and *Salamandra salamandra*. In his work adults that had been acclimated to 10° and 30°, respectively, were transferred to a 0° environment. The high-acclimated group proved to be inactive at 0°, but the other active. In addition Mellanby indicated that the length of exposure is an important factor in temperature acclimation, a factor that has been investigated quite extensively in fishes by Doudoroff (1942), Fry, Hart and Walker (1946) and Brett (1946).

A number of papers relate geographic distribution of some amphibians to rates of development, temperature tolerances, etc. (Moore, 1949; Volpe, 1952). These reports are not concerned with the individual adaptation of the organism, but deal, rather, with reactions of

eggs to temperature. The results indicate that such differences as found are on a genetic level and hence involve physiological races at least.

Because of the scarcity of information on this subject it was decided to determine what effect acclimation has upon the California newt, *Taricha torosa* (= *Triturus torosus*) with respect to upper lethal temperatures. Forty-three specimens of *T. torosa* were collected from Boulder Creek, San Diego Co., California on May 10, 1953, for the purposes of the experiments. This work was supported by a grant from the Richfield Oil Corporation and was done under the direction of Dr. R. B. Cowles and Mr. Bayard H. Brattstrom, Department of Zoology, University of California, Los Angeles.

APPARATUS AND METHODS

The specimens were brought to the laboratory and divided into three experimental groups and placed in three separate aquaria, the water temperatures of which were maintained at 10.0°, 22.0° and 30.0° C., respectively. Twelve animals were used in two of the experimental groups (10° and 30°) and 19 in the other (22°). All the animals were acclimated for a period of one week before the lethality tests were performed. A 10-gallon aquarium, used for all lethality tests, was equipped with a 50-watt submersible heater and an adjustable aquarium-type thermostat. The experimental temperatures used were 33.5°, 36.0° and 38.0° C.

The animals acclimated at 10° and 30° were introduced into water at 22.0° for one hour before being placed in the lethal tank. This was done in an attempt to ease somewhat and equalize the initial shock caused when animals

are put in a higher temperature medium. The lapsed time between introduction into the experimental tank and death was recorded. Animals were placed in the experimental tank in groups of four.

The exact moment when death occurred was difficult to determine in these animals, but was arbitrarily assumed to have taken place when equilibrium was lost and there was no response to probing with a glass rod. If the animals were left in the tank for a few minutes after no reaction was obtained, they would not recover when removed to a lower temperature. When immediately removed to a lower temperature, however, they would recover.

EXPERIMENTAL RESULTS

None of the animals died when placed in the test tank kept at 33.5° regardless of the acclimation temperature. In the animals introduced to 36.0° the time to death varied depending on the temperature at which they were acclimated. Thus, the animals from 10.0° lived for an average of 7.3 minutes, those from 22.0° for an average of 19.5 minutes; two of the animals from 30.0° were still alive after more than 3 hours in the tank, the other two dying at 2 hours and 20 minutes. When introduced into 38.0° water those animals from 10.0° succumbed, on the average, in one and one-half minutes; those from 22.0°, in one minute and 45 seconds. The animals acclimated to 30.0° resisted this lethal temperature for an average of 6 minutes and 53 seconds. It thus appears that resistance of these animals to upper lethal temperatures is markedly modified by their past thermal history. (Table I).

DISCUSSION

In *Taricha torosa* the upper lethal limit with respect to temperature lies somewhere between 33.5° and 36.0° when the temperature of acclimation is between 10.0° and 30.0°. Such a differential has been taken by many workers to indicate physiological adaptation to temperature (Jacobs, 1919; Hathaway, 1927; Fry, 1947; Brett, 1946). Most of these workers designate mortality as the average time at which 50 percent of the individuals of a group succumb. Such an index was impracticable to use in the present experiments because of the difficulty of ascertaining the individual mor-

TABLE I
SURVIVAL PERIOD OF *Taricha torosa* ACCLIMATED AT DIFFERENT TEMPERATURES

Experimental temperatures, °C.	Acclimation temperatures, minutes of survival and numbers of salamanders (in parentheses)		
	10° C.	22° C.	30° C.
33.5	No deaths (2)	No deaths (2)	...
36.0	6½ (3) 9 (1)	19½ (4)	No deaths (2) 140 (2)
38.0	1½ (4)	1¾ (4)	4½ (1) 6 (1) 8½ (2)

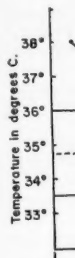


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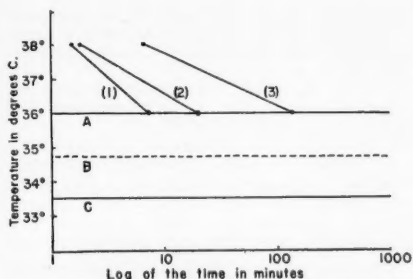


Fig. 1. Relationship between the acclimation temperature and the time to 100-percent mortality at various experimental temperatures in *Taricha torosa*.

Abscissa equals the logarithm of the mean time to 100-percent mortality (plotted as a log function because of findings of Fry, *et al.*, 1946 with respect to same relationship in trout). Ordinate equals lethal temperature expressed in degrees centigrade. Diagonal lines (1), (2) and (3) represent the acclimation temperatures 10°, 22° and 30°, respectively. Line A represents the upper lethal temperature above which 100-percent mortality always occurred. Line C represents the lower upper lethal temperature below which 100-percent mortality never occurred. Line B is the average between line A and C and equals 34.75°. This line is an extrapolation from the data and has no reality in itself, but is an average of the temperatures representing absolute survival or death. With qualification it may be used as a single figure representing the lethal temperature for *T. torosa*.

talities as such, and the closeness of the individual deaths in each introduced group. For this reason 100-percent mortality was used and an average of the death time taken to indicate it. (Fig. 1).

Acclimation in aquatic phases of salamanders, as in many fishes and invertebrates, is a definite factor in determining lethal temperature. Thus, to give the lethal temperature for *T. torosa* and other aquatic amphibians without some indication of past thermal history is misleading. To be sure the upper lethal temperature at 36.0° is not the highest temperature to which *T. torosa* can be exposed. For shorter periods of time this salamander can withstand water temperatures as high as 38.0°.

The behavior of the variously acclimated groups when introduced into lethal temperatures indicates that the cause of death is similar in all. The behavioral reactions varied somewhat but merely in degree; death was always preceded by rigor.

On being put in the experimental tank at 36.0°, the 10°-acclimated group responded with vigorous swimming movements. These continued for about 5 minutes; then the salamanders slowed down to a sluggish uncoordinated pattern of undulations of the entire

body rather than that of the tail alone as in normal individuals. Following this the animals showed a complete loss of equilibrium; they turned upside down and slowly moved the appendages. At 7.3 minutes no response could be obtained and the group was considered dead. The 22°-acclimated group showed similar responses with a prolongation of survival time. Lastly, in both groups there occurred a stiffening of the body, here interpreted as heat rigor. The 30°-acclimated group showed the same initial response of swimming vigorously about the tank. The period of swimming, however, was much shorter than that of the two previous groups, and at its end, the animals settled down and showed well coordinated movements for more than 2 hours. In the two animals that died the response was similar to that of the other groups.

In the experimental tank at 38.0° the 10°-acclimated group reacted by swimming violently and wildly about the tank for about one minute, and then settled to the bottom with mouths agape. Equilibrium was lost and heat rigor set in within 15 seconds. Reaction to probing was absent by one and one-half minutes. The 22°-acclimated group reacted in a like manner succumbing at one minute and 45 seconds. The 30°-acclimated group reacted similarly to the above two groups, but a loss in equilibrium was not noticed until after 3 minutes had passed, the group succumbing at an average of 6.9 minutes.

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Histology of the Digestive Tract and Adjacent Structures of the Rainbow Trout, *Salmo gairdneri irideus*

EVA LURIE WEINREB AND NELLIE M. BILSTAD

INTRODUCTION

THE literature contains many descriptive studies of the anatomy and histology of the digestive tract of fish. Early papers include one by Oppel (1896) on the histology of trout and one by Gulland (1898) on the salmon. Among the more complete histological studies reported are those of the Characidae by Rountree (1903), which also takes into account the ductus pneumaticus, the king salmon by Greene (1912), the plaice by Dawes (1929), the minnow by Rogick (1931), the sea bass and sea robin by Blake (1930, 1936), the Cyprinoidae by Pictet (1909), the carp by Curry (1939), and a bottom-feeder and plankton-feeder by Al-Hussaini (1946-1947).

Studies on the structure, embryology and physiology of the swim bladder have been done by Hall (1924), Hoar (1937), McEwen (1940), Dobbin (1941), Jones (1951), and Scholander and coworkers (1951). The histological descriptions of the swim bladder have been mainly in the physoclisti with special reference to the gas gland and rete mirabile, whose physiology and structure are discussed by Hall (1924).

It is the purpose of this study on the rainbow trout, *Salmo gairdneri irideus* Gibbons, to describe the histology of the digestive tract, the liver and pancreas, and the detailed relationship of the swim bladder and its duct to the esophagus. A study was also made to determine sites of phagocytosis. Histochemical tests were made on the granule cells of the stomach and

intestine preliminary to further studies concerning their functions. Mucopolysaccharide and alkaline phosphatase tests were made on the entire tract and swim bladder in an attempt to correlate the presence of these materials and possible areas of absorption. The time of the appearance of the strata compactum and granulosa was determined in fingerlings.

MATERIALS AND METHODS

Male and female rainbow trout ranging in size from six to fourteen inches were supplied for this study by the fish hatchery of the Wisconsin Conservation Department. The fish were killed quickly by a blow on the head. Particular care was taken to insure rapid fixation in order to stop digestive processes.

For the gross histology of the tract a number of fixatives were used including Bouin's, Helly's, 10 percent buffered formalin, Rossman's (picro-alcohol-formalin), and Carnoy's acetic-alcohol (both with and without chloroform). The tissues were stained with McFarlane's modification of Mallory's triple stain (using picro-Biebrich's scarlet and aniline blue), iron hematoxylin and fast green with mucicarmine, and Harris' hematoxylin with eosin or eosin-azure. For most routine studies McFarlane's triple stain was found to be satisfactory. Special staining procedures used included the Gomori technic for the islet cells in the pancreas (Gomori, 1939), the silver method for reticulum (Dublin, 1946), the

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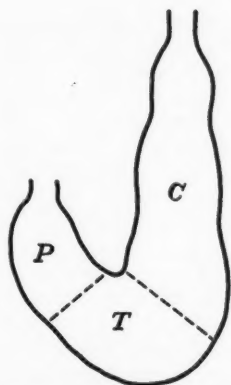


Fig. 1. Outline of the stomach of the rainbow trout ($\times 1.1$), indicating the three regions into which it is divided: C, cardiac; T, transitional; P, pyloric.

Bauer technic for glycoproteins (Lillie, 1948), Regaud's and Severinghaus' methods for mitochondria (Guyer, 1947), and the various histochemical tests listed below.

The figures in Plates I-IV were made from sections fixed in Bouin's solution. These photomicrographs were made with the Leica and Leitz Micro-ibso attachment. Wratten filters Nos. 5 and 22 were used in combination for all photomicrographs, with the exception

of Figs. 13 and 14 for which filters 47 and 29 were used, respectively.

GROSS ANATOMY

The short muscular esophagus gradually enlarges at the junction with the long arm of the J-shaped stomach. Externally there is no sharp line of demarcation between the esophagus and stomach. The stomach consists of three regions: the cardiac, intermediate or transitional, and pyloric (Fig. 1).

Following removal of the overlying caeca, the pyloric valve is visible as a tough, muscular region marked by a slight constriction. If this region is opened longitudinally, a prominent circular shelf is seen at the intestinal end of the valve. This shelf projects forward into the intestinal lumen. The intestinal tract is composed of two parts: a short ascending limb, and a longer descending limb extending posteriorly to the anus (Fig. 2).

Pyloric caeca originate from the lateral and posterior surfaces of the bend of the ascending limb as blind finger-like extensions. The caeca are embedded in a fatty mass which also extends over the pyloric region of the stomach (Fig. 2).

The liver is composed of a single saddle-shaped mass with only superficial depressions

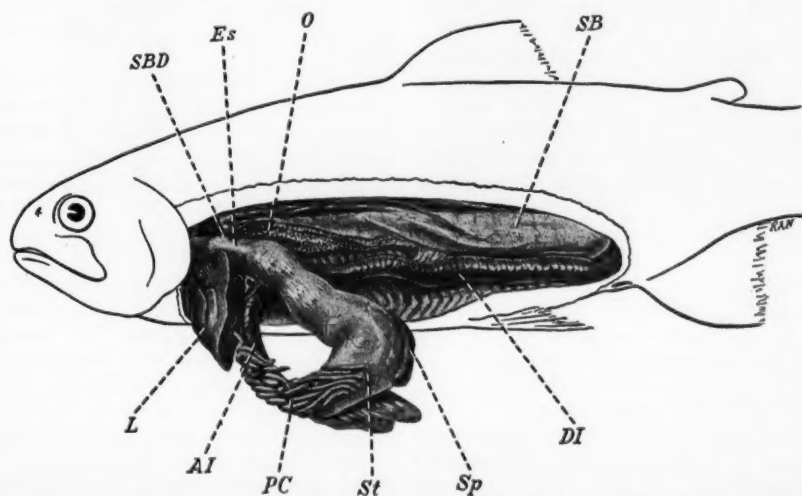


Fig. 2. Viscera of the rainbow trout, showing the relationship between the digestive tract and adjacent organs ($\times \frac{1}{2}$). Overlying fat was removed from the caeca, intestine, and stomach, and the left ovary was removed. AI, ascending intestine; DI, descending intestine; Es, esophagus; L, liver; O, ovary; PC, pyloric caeca; SB, swim bladder; SBD, swim bladder duct; Sp, spleen; and St, stomach.

indicating divisions into lobes. In the rainbow trout the pancreas is a diffuse gland, lying on the surface of the fatty lobules which are located between the pyloric caeca.

The swim bladder is an elongated retro-peritoneal sac, covered by peritoneum only on the ventral surface. It is closely adherent to the body wall dorso-laterally and to the kidneys dorsally. In the trout the length of the bladder is equal to three-fourths the length of the body cavity, as previously reported by Dobbin (1941). The pneumatic duct passes ventrally from the anterior portion of the swim bladder to the dorsal wall of the esophagus. This duct lies in loose connective tissue anterior to the body cavity and is enclosed by peritoneum on the posterior and lateral surfaces only. Other types of swim bladders and their duct connections are described by Rountree (1903).

HISTOLOGY

ESOPHAGUS.—The esophagus is composed of the usual four layers: mucosa, submucosa, muscular coat, and serosa (Pl. I, Fig. 3).

The **mucosa** bears large primary folds with numerous secondary foldings. The mucosa shows a gradual change in both surface epithelium and glands from the pharynx to the stomach. Two types of glands are found. Anterior to the level of the pneumatic duct, tubular mucous-secreting esophageal glands are present, while anterior to the level of the duct entrance, serous cardiac glands begin and are continuous with similar glands of the cardiac stomach. These glands are absent surrounding the point of entrance of the duct. At the pharyngeal end, the surface epithelium is a stratified cuboidal type containing occasional goblet cells. The surface cuboidal cells have very fine striated borders. As the esophageal mucus glands become prominent, this stratified epithelium is restricted to the tops of the folds. The sides of the folds contain the same two cell types found in the glands, a prominent goblet-like mucus cell and a very narrow columnar cell with an indistinct striated border. The nucleus of the second type of cell is located distally where the cytoplasm flares over adjacent mucus cells.

In the surface epithelium anterior to the cardiac glands, these two cell types are re-

placed by tall columnar cells, similar to those of the gastric mucosa. This epithelium rests on small, irregular cells, often two to three cells deep. These cells resemble those found in king salmon by Greene (1912) and in sea bass by Blake (1930). They have indistinct outlines and scanty cytoplasm, with dense nuclei similar to those found in lymphocytes. These cells, although primarily at the base of the columnar cells, are also found at all levels of the epithelium. They appear to be in stages of migration through the upper regions of the mucosa. In some specimens, particularly young fish, many of these cells were found to be undergoing mitosis. In the region of the swim bladder duct, the mucosal folds of the esophagus become more extensive.

The **submucosa** is made up of a thick layer of loose areolar connective tissue containing fibroblasts and numerous granule cells. There is no sharp line of demarcation between this extensive connective tissue layer and the finer tissue of the tunica propria which lies between and around the glands.

The **muscularis externa** forms half the thickness of the organ, and is composed of interweaving striated muscle bundles forming a circular coat. At the point of entrance of the swim bladder duct the muscle bundles part and curve above and below the duct.

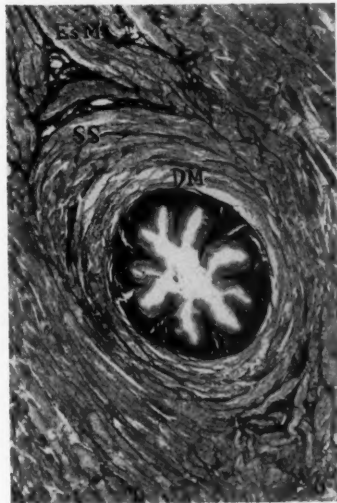
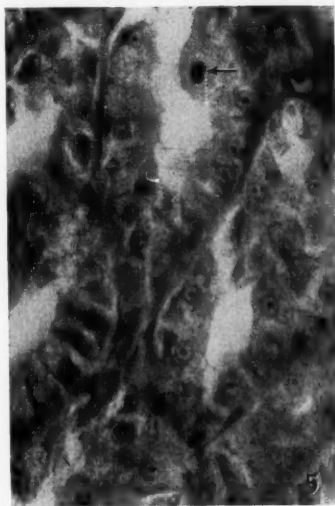
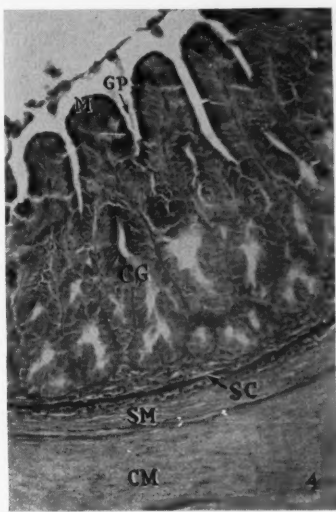
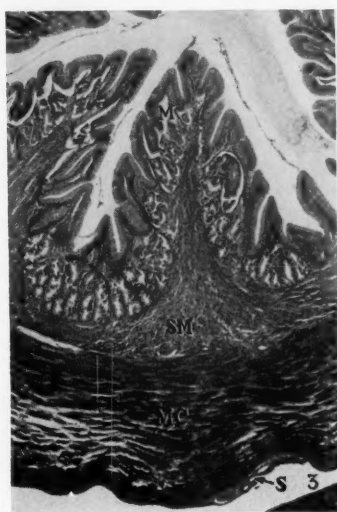
The **serosal layer** is composed of typical mesothelial cells and supporting connective tissue.

STOMACH.—The stomach is composed of the typical four layers (Pl. I, Fig. 4). The mucosa includes the surface epithelium and cardiac glands, tunica propria, stratum compactum, stratum granulosum, and muscularis mucosae. Because of its varying histology the stomach may be divided into three gross regions: cardiac, transitional, and pyloric (Fig. 1).

The gastric **mucosa** is thickest in the cardiac stomach, due to the abundant cardiac glands, and thinnest in the pylorus. The mucosa forms rugae, the depth of which depends upon the degree of distention of the stomach.

Surface epithelium and glands of cardiac stomach: The mucosa of the cardiac stomach is marked by gastric pits which lead into the cardiac glands (Pl. I, Fig. 4). These pits vary in depth, usually extending through one-third of the mucosa. The surface epithelium is

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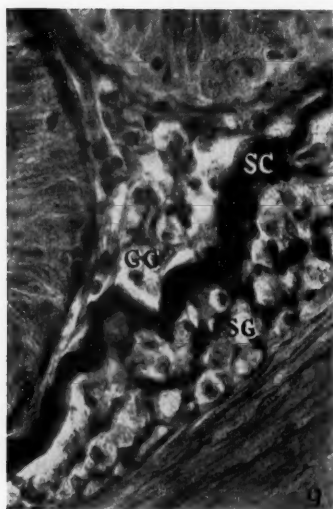
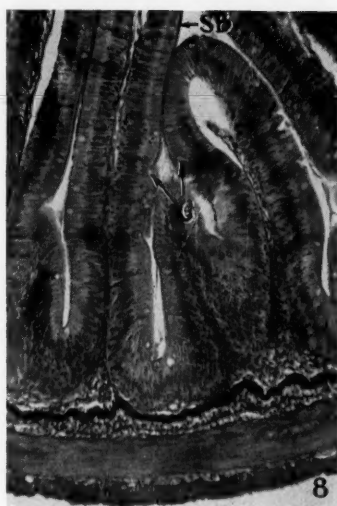
Photomicrographs of digestive tract of rainbow trout

Fig. 3. Cross-section of the esophagus at the level of the cardiac glands, showing the mucosa (M), submucosa (SM), muscle coat (MC), and serosa (S). Triple stain; $\times 41$.

Fig. 4. Cross-section of the cardiac stomach, showing the mucosa (M), submucosa (SM), circular muscle coat (CM), gastric pits (GP), cardiac glands (CG), and stratum compactum (SC) indicated by the arrow. Iron hematoxylin, fast green, and mucicarmine; $\times 113$.

Fig. 5. Cross-section of the serous glands of the stomach. Mitotic figures are indicated by the arrow. Iron hematoxylin, fast green, and mucicarmine; $\times 498$.

Fig. 6. Cross-section of the swim bladder duct in its path through the esophageal musculature (EsM). The outer skeletal sphincter (SS), indicated by the arrow, can be distinguished from the inner smooth muscle bundles of the duct (DM). Triple stain; $\times 41$.



Photomicrographs of digestive tract of rainbow trout

Fig. 7. Cross section of the pyloric stomach, showing one ruga, with mucous secretion (M), shallow glands (G), and pits (P). Iron hematoxylin, fast green, and mucicarmine; $\times 113$.

Fig. 8. Cross section of the descending intestine, showing the striated border (SB) and goblet cells (G), indicated by the arrows. Triple stain; $\times 113$.

Fig. 9. High power view of the strata compactum (SC) and granulosa (SG) with granule cells (GC) of the descending intestine. Triple stain; $\times 498$.

Fig. 10. Cross section of the pyloric caecum, showing the striated border (SB), indicated by the arrow, and pancreatic tissue (P) external to the caecal wall. Triple stain; $\times 113$.

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The cardiac glands are simple, sometimes branched, tubular glands located below the level of the gastric pits. The surface epithelium extends into the pits as far as the mouth of the gland. Toward the base of the pit the top plate of mucous secretion gradually decreases. Each gland consists of four portions, the mouth opening into the pit, the small constricted neck portion, the body of the tubule, and the fundus or slightly dilated end portion. The neck cells are simple columnar cells without the mucus top plate. The gland cells of the body and fundus are serous, and are similar in appearance to the chief cells in other animals (Pl. I, Fig. 5). These cells, which are similar to those described by Green (1912) in the king salmon, contain abundant zymogen granules concentrated toward the lumen of the gland. The cardiac glands of the esophagus have essentially the same histology as those of the cardiac stomach.

Pyloric stomach: Due to the extreme contraction of the pyloric stomach, the surface mucosa is thrown into a network of folds, between which broad pits lead to very shallow glands (Pl. II, Fig. 7). The surface epithelium closely resembles that of the cardiac stomach. The cells of the short basal glands are mucous secreting, and are approximately two-thirds the height of the surface cells.

Transitional zone: The region of the bend and an adjacent portion of the short arm of the stomach constitute an intermediate or transitional zone. In this zone the short pits of the cardiac region lengthen to resemble the deeper pyloric pits; the branched serous glands shorten, and are gradually replaced by shorter mucus glands like those of the pyloric stomach.

Tunica propria: The tunica propria consists of a fine network of loose areolar connective tissue and a dense network of reticular fibers, supporting capillaries, lymphatics, and occasional ganglia. This connective tissue layer is the same throughout the stomach, the only variation being the greater thickness in the pyloric region.

Stratum compactum: Beginning in the anterior cardiac region and extending posteriorly the length of the digestive tract, there is a prominent membrane which completely

encircles the tract. In section it appears as a wavy, structureless band directly external to the tunica propria. With routine staining, it has an acellular, hyaline appearance. Its staining is similar to that for collagenic fibers, but is darker by virtue of its greater density. Cells on this layer are of two types, the fibroblasts of the tunica propria and the granule cells of the stratum granulosum. Although collagen fibers are present, a distinct compactum is not found prior to the fourteenth week in the fingerling.

Stratum granulosum: External to the compactum numerous large granule cells form an almost continuous layer. They are often completely or partially enclosed by collagenic extensions from the compactum. These cells are also abundant in the adjacent tissue layers, particularly the tunica propria. The nucleus is displaced to one side by the abundant large, round granules which fill the cytoplasm. Filamentous mitochondria, supravitaly stained with Janus Green B, are visible between the granules. These cells are present by the twelfth week in the fingerling.

Muscularis mucosae: Adjacent to the cells of the stratum granulosum, smooth muscle fibers form an irregular network of varying thickness.

The **submucosa** consists of a very thin layer of areolar tissue containing scattered granule cells.

Posterior to the junction of the esophagus and cardiac stomach, the striated fibers are gradually replaced by the smooth muscle which forms the usual inner circular and outer longitudinal muscle layers which continue along the remainder of the tract. The usual thickening of the circular coat occurs at the pylorus.

A very vascular **serosa** forms the outermost layer.

PYLORIC VALVE.—In longitudinal section, the pyloric valve can be identified by the marked thickening of the circular musculature and by the unique mucosal projection which forms the circular shelf (Pl. III, Fig. 11). The pits of the pyloric mucosa gradually decrease in depth as this mucosa blends with that of the valve. In the absence of mucosal glands the inner coat of the valve more closely resembles that of the intestine than of the stomach. The epithelium of the valve is composed of both

columnar and goblet cells, supported by dense fibrous connective tissue. The stratum compactum is not visible all along its length, but is lost in the muscle and connective tissue layers. The granule cells of the stratum granulosum are scattered throughout the underlying muscle coat and adjacent connective tissue. The circular muscle coat is interrupted by dense connective tissue fibers, while the longitudinal coat is continuous with that of the stomach and intestine as is the serosa.

INTESTINE.—The intestine is composed of three major layers: the mucosa, muscularis, and serosa (Pl. II, Fig. 8). Like the king salmon described by Greene (1912), the trout intestine lacks a true submucosa and a muscularis mucosae. The mucosa, like that of the stomach, contains a stratum compactum and stratum granulosum.

The **mucosa** is thrown into longitudinally arranged slender folds bearing occasional secondary folds which are more numerous in the ascending limb. A slender core of loose connective tissue supports the primary fold.

The surface epithelium consists of goblet cells and columnar cells with a distinct striated border. At the base of the columnar epithelium there are numerous small, round cells like those found in the esophagus. These cells are also found within the columnar cells where they show stages of degeneration. Similar cells were reported in the intestine of king salmon by Greene (1912), in *Pleuronectes platessa* by Dawes (1929), in *Centropristes striatus* by Blake (1930), and in carp by Curry (1939). Cells of this type have been described as lymphocytes by Pictet (1909) and wandering leucocytes by Greene (1912).

The tunica propria contains abundant reticular fibers supporting numerous lymphatics and blood vessels, infiltrated with leucocytes, small "wandering" cells, and granule cells from the granulosum. The strata compactum and granulosum of the intestine (Pl. II, Fig. 9) are the same as the corresponding layers in the stomach.

The **muscular coats** are the same in arrangement as in the stomach. The circular layer is slightly thicker in the ascending limb and is more than twice the thickness of the longitudinal layer in both limbs. The circular muscle thickens at the opening of the caeca into the

intestinal wall (Pl. III, Fig. 12), indicating a possible sphincter action.

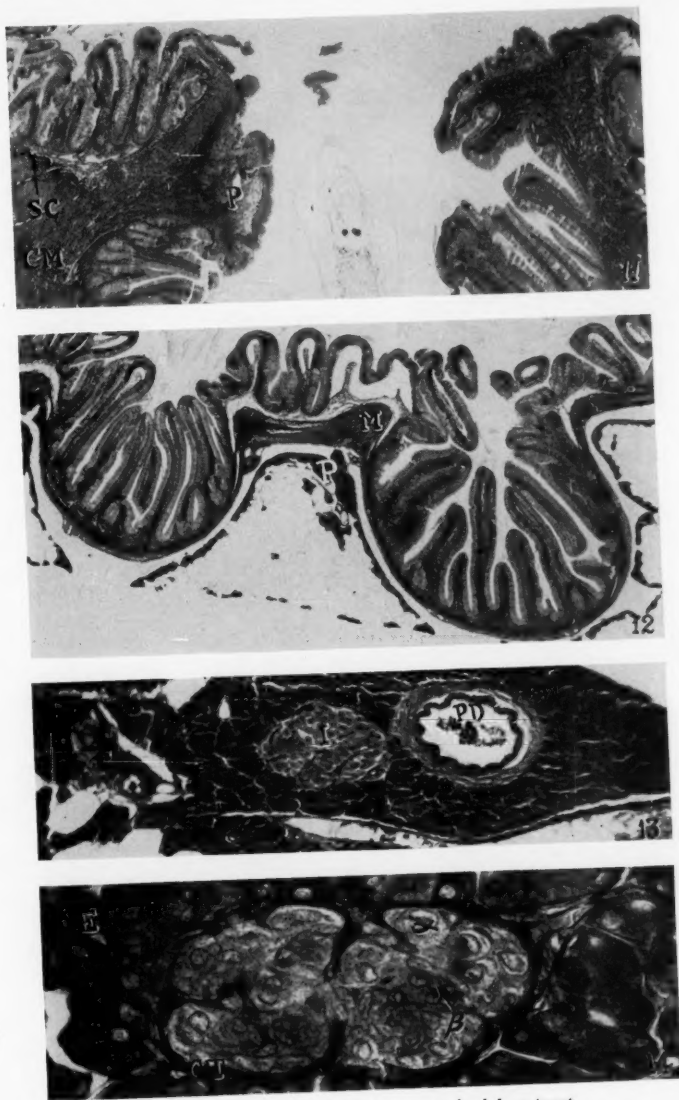
The **serosa** of the ascending limb is continuous over the surface of the caeca.

PYLORIC CAECA.—The gross histological structure of the pyloric caeca is very similar to that of the ascending intestine from which it is derived. The same coats are present, but a few differences exist. The longitudinal folds of the mucosa are more slender and show no secondary folding (Pl. II, Fig. 10). The surface epithelial cells contain masses of fat droplets, which Greene (1911) associated with the process of fat absorption in king salmon.

LIVER.—The liver is covered by an outer serosa continuous with the peritoneum. The connective tissue capsule extends into the liver along the ducts and major blood vessels and their branches. In the trout the lobules of the liver are poorly defined.

Each lobule consists of many anastomosing hepatic sheets radially arranged around the central vein (Pl. IV, Fig. 17). In the trout the laminae, typical of lower vertebrates as described by Elias (1952), are two cell layers in thickness, in contrast to the single-celled sheet described in mammals by the same author (1949a, 1949b). At the periphery of the lobules the bile ducts and branches of both the portal vein and hepatic artery occasionally form portal triads, but are more commonly found singly. The hepatic sinusoids are lined by two cell types, the one more flattened and resembling the less active reticular cell of the mammal, and the other the more phagocytic, von Kupffer-type cell. Very fine bile ducts, lined by flattened cells, originate between the two layers of a lamina and pass peripherally into the interlobular bile ducts (Pl. IV, Fig. 17). Abundant pigment is deposited along this duct system, as well as along the interlobular arteries. This pigment is positive for melanin as shown by the Bodian method according to Dublin (1943). Abundant fat vacuoles are found in the hepatic cell. Tests for iron and bile pigment were negative.

The common bile duct penetrates the pancreatic tissue and emerges with the pancreatic duct. The common bile duct is encircled by a smooth muscle sphincter as it penetrates the ascending intestine slightly anterior to the pancreatic duct.



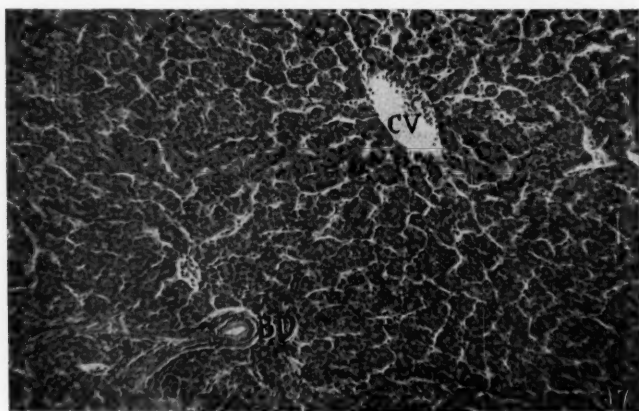
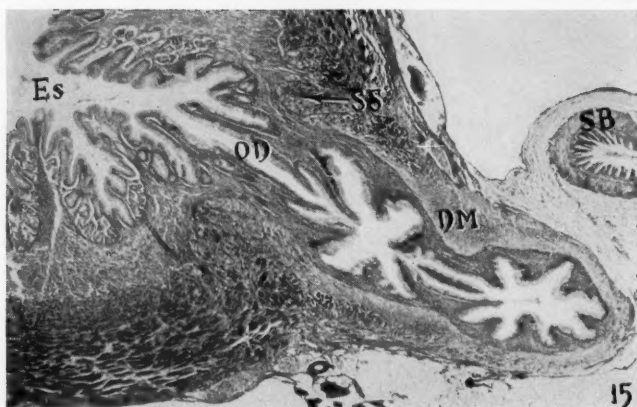
Photomicrographs of digestive tract of rainbow trout

Fig. 11. Longitudinal section of the pyloric valve region, showing the circular muscle (CM), and stratum compactum (SC) indicated by the arrow. The projection (P) extends anteriorly towards the intestine. Triple stain; $\times 31$.

Fig. 12. Cross section of the intestine with two pyloric caeca, showing muscle thickenings (M), and pancreas (P) lying on the fat masses between the caeca. Triple stain; $\times 31$.

Fig. 13. Section of pancreatic tissue, showing a large pancreatic duct (PD) and group of islet cells (I). Gomori stain; $\times 113$.

Fig. 14. High power view of islet cells among the exocrine cells (E). The lighter, peripheral cells are similar to alpha cells (α), and the darker, central cells, below the arrow, resemble beta cells (β). The connective tissue sheath (CT) encloses the islet cells. Gomori stain; $\times 498$.



Photomicrographs of digestive tract of rainbow trout

Fig. 15. Cross-section of the esophagus (Es), showing the opening of the swim bladder duct (OD), the circular smooth muscle of the duct (DM), and its replacement by the skeletal sphincter (SS) indicated by the arrow. A portion of the swim bladder (SB) is visible. Triple stain; $\times 31$.

Fig. 16. Cross section of the wall of the swim bladder, showing the folded mucosa (M), muscle coats (MC) and outer fibrous coat (OFC). Triple stain; $\times 113$.

Fig. 17. Section of the liver, showing the hepatic sheets radiating from the central vein (CV) and an interlobular bile duct (BD) with small masses of pigment along its branches. Triple stain; $\times 113$.

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PANCREAS.—Unlike the pancreas of the carp, as described by Smallwood and Derrickson (1933), the trout pancreas does not extend into the liver. The pancreatic tissue is spread over the surface of fatty tissue surrounding the caeca, and is more compact in the region of the large pancreatic duct. The pancreas consists of two typical portions, the compound tubular exocrine portion and the smaller scattered groups of islet cells (Pl. III, Fig. 13). The exocrine cells are typical pancreatic acinar cells.

The Islets of Langerhans vary greatly in size. The larger groups are enclosed by a connective tissue sheath (Pl. III, Fig. 14). No islet tissue was located in the more diffuse areas over the fatty tissue, but islets of all sizes were found in the compact portions. Using the Gomori modification of the Mallory-Heidenhain azan stain (Gomori, 1939), two distinct cell types are distinguishable (Pl. III, Fig. 14). With this technic the more finely granular peripheral cells show the characteristic staining reactions of the mammalian alpha cells, while the more coarsely granular centrally located cells show the reactions characteristic of the mammalian beta, insulin-producing cells. The third type, the gamma cells, described in many animals including the gray snapper, *Lutjanus* (formerly *Neomaenis*) *griseus*, by Bowie (1924), was not found in the rainbow trout.

SWIM BLADDER.—The swim bladder consists of three coats: the mucosa, muscular coats, and outer fibrous coat (Pl. IV, Fig. 16).

The **mucosa** is thrown into very low, longitudinal folds which are not evident when the bladder is distended. The epithelium is composed of two types of cells, the predominant large mucous-secreting cells, and a few ciliated low columnar cells. These ciliated cells increase in number near the opening to the pneumatic duct. The free margin of the larger cells is heavily laden with mucus. Beneath this margin of mucus and extending into it are numerous prominent vacuoles. The loose connective tissue of the tunica propria becomes more compact next to the muscle layers.

The **muscle coats** are the heaviest of the three layers. Interweaving smooth muscle bundles form an inner circular coat and a thinner outer longitudinal coat. The outermost portion is interrupted by large capillaries.

The bladder is surrounded by loose areolar connective tissue, forming the **outer fibrous coat**, which also encloses the duct. The ventral surface becomes a serosa with addition of the mesothelial layer continuous with that of the body cavity.

SWIM BLADDER DUCT.—The duct is composed of layers very much like those of the esophagus. It lies in loose connective tissue anterior to the body cavity. The posterior and lateral surfaces of this connective tissue are enclosed by peritoneum. Blood vessels, ganglia, and nerves are numerous along the length of the duct, the ganglia and nerves becoming especially prominent at the entrance of the duct into the esophageal wall (Pl. IV, Fig. 15).

The **mucosa** forms longitudinal ridges. The epithelium is composed of the same cell types found within the swim bladder, the ciliated columnar cells being predominant. At the base of the epithelial layer numerous small, round cells are found similar to those found in the esophagus.

The heavy connective tissue fibers of the **submucosa** are continuous with the finer areolar tissue extending into the mucosal folds.

The **muscle layer** is composed of circularly arranged smooth muscle bundles. This coat comprises more than half the thickness of the duct. With the progression of the duct through the esophageal musculature, a sphincter of striated muscle appears external to the smooth muscle of the duct (Pl. I, Fig. 6). By the time the duct penetrates the submucosa of the esophagus, the smooth muscle has almost disappeared and been replaced by this striated sphincter. This sphincter is not completely separate from the esophageal musculature, since fibers from the outer part of the sphincter continue into the main esophageal coat. In this region, branching of the striated muscle fibers is especially evident.

SITES OF PHAGOCYTOSIS

Thorotrast (Heyden Chemical Corp., New York), as employed in amphibians by Easton (1953), was used as a means of determining phagocytic activity in the digestive and accessory organs. Seven-inch trout were anaesthetized in dilute urethane and the Thorotrast injected intraperitoneally in dosages from 0.1 ml. to 0.4 ml. The animals were sacrificed

following 3, 5, 7, and 10 days. Optimal results were obtained with the 0.4-ml. dose.

The distribution of Thorotrast particles was similar in all parts of the digestive tract. The finer particles were visible in branched histiocytes, while larger particles were clumped in the macrophages. These were located in the submucosa of the esophagus, the tunica propria and submucosa of the stomach, and the tunica propria of the intestines and caeca. Macrophages were also located between the muscle bundles and between the submucosa and muscle coat in the esophagus. The Thorotrast was not present in the epithelial cells. In all organs fine granulation was found in the endothelium of the lymphatics.

The sites of concentration of Thorotrast were in the liver and spleen. Large particles filled macrophages in the liver sinusoids, while smaller particles were present in the von Kupffer cells. Fine granulation was found in the hepatic cells with orientation toward the bile canaliculi. Minimal peripheral necrosis occurred around the bile duct in the fish killed after 3 and 5 days, but was absent by the 7th day. Fine granulation was also found in the endothelium of the hepatic veins. The lumina of the veins contained abundant granulation. The path taken through the liver followed that of the circulation; Thorotrast being brought to the liver from the digestive tract and spleen via the hepatic portal vein, and leaving by way of the bile duct and hepatic veins. In most instances the large macrophages in the hepatic sinusoids are probably histiocytes from the spleen. The phagocytic cells in the digestive organs are granulocytes located in the tunica propria and submucosal layers; the granule cells of the stratum granulosum are not involved.

HISTOCHEMISTRY OF THE GRANULE CELLS

The granule cells of the digestive tract have been studied by various means to determine their structure and functions. For an extensive review of the literature the reader is referred to Bolton (1933) and Al-Hussaini (1949). Various sources have been suggested as to their origin, including eosinophils, lymphocytes, and connective tissue. Granules in these cells were found in different fish to be basophilic (Bolton, 1933), acidophilic (Greene, 1912), basophilic

changing to acidophilic (Jordan, 1926), and both acidophilic and basophilic (Al-Hussaini, 1949), depending on the tissues and technics employed. Bolton (1933) found the granules were destroyed by weak acids and bases in fresh tissue, but unaffected following Helly's fixation. Using various fixing solutions, he found that alcoholic solutions with formalin or mercury bichloride and aqueous mercury bichloride were best. Granules, however, were destroyed by acetic acid and not fixed by osmic acid.

Al-Hussaini (1949) found that the granule cells fell into two categories, those which were basophilic, as in *Salmo trutta* and *Trigla birundo* and those which were acidophilic, in the other species studied. No definite conclusions may be drawn from past reports on these cells, since studies on the granule cell differ with the species of fish and the technics used.

In order to learn something of the chemical nature and possible functions of the granule cells in rainbow trout, a series of histochemical tests were made. These tests were divided as follows: polysaccharides, proteins and amino acids, lipids, mitochondrial technics, pigments, and enzymes. The fixatives and technics used are given in Table I.

The size and shape of the granules varies with the fixative used. Optimal fixation was obtained with Helly's, 10 percent buffered formalin, and the mitochondrial fixatives of Regaud and Champy. Carnoy's acetic-alcohol resulted in loss of part of the granule, while osmic acid failed to preserve the granules. The chemical structure of these granules appears to be that of a protein core containing arginine, an outer lipid-phospholipid shell, and a trace of non-acid mucopolysaccharide. Since these granules fail to stain metachromatically following fixation in basic lead acetate, the test for heparin, these cells are not comparable to mast cells. It is also evident from the negative tests for iron pigments and bilirubin that the cells are not directly involved in hemoglobin breakdown.

MUCOPOLYSACCHARIDES AND SITES OF ALKALINE PHOSPHATASE ACTIVITY

The lining epithelium of the entire digestive tract and swim bladder were tested for neutral mucopolysaccharides (n.MPS) using the peri-

Polysacc

Glycogen,

Glycogen

Mucin

Acid muc

Sulfated a

Heparin

RNA

DNA

Proteins

Total prot

Basic prot

Arginine¹

Tryptoph

Tyrosine

Lipids:

Total lipid

Lipid-phos

Mitochon

Pigments

Melanin

Hemosider

Fe⁺⁺

Bilirubin

Enzymes:

Alkaline p

Acid phosph

Lipase

Peroxidase

DOPA oxid

Ascorbic ac

¹ Positive
² Weakly
³ Control:
alcohol—no

TABLE I
HISTOCHEMICAL TESTS

Material	Fixative	Technic
Polysaccharides:		
Glycogen, mucin glycoprotein, etc. ²	Rossman's	Periodic acid-Schiff's reagent (Lillie, 1948)
Glycogen	Rossman's	Best's carmine (Lillie, 1948)
Mucin	Rossman's	Mayer's mucicarmine; Mayer's mucihematein (Lillie, 1948)
Acid mucopolysaccharides	Rossman's	Prussian blue reaction (Rinehart and Abul-Haj, 1951)
Sulfated acid mucopolysaccharides	Rossman's acetic-alcohol, formalin	Toluidin blue (Gomori, 1952)
Heparin	Basic lead acetate (Sylvén)	Toluidin blue (Cowdry, 1948)
RNA	Rossman's, Helly's	Basic staining, toluidin blue
DNA	Rossman's, Helly's	Feulgen (Glick, 1949)
Proteins and amino acids:		
Total protein ¹	Rossman's, Helly's, Bouin's	Mercuric-bromphenol blue (Mazia, <i>et al.</i> , 1953)
Basic protein ¹	Rossman's, Helly's, Bouin's	Bromphenol blue (Mazia, <i>et al.</i> , 1953)
Arginine ¹	Helly's, Rossman's	Modified Sakaguchi reaction (Thomas, 1946)
Tryptophane	Helly's	Romieu's (Glick, 1949; Serra, 1946)
Tyrosine	Helly's	Modified Millons' (Gomori, 1952; Serra, 1946)
Lipids:		
Total lipid ¹	Formalin-fixed, frozen sections	Jackson's acetic-carbol-Sudan III (Glick, 1949)
Lipid-phospholipid ^{1, 2}	Formalin-fixed, frozen sections	Sudan black B
Mitochondrial:		
	Regaud's ³ ; modified Champy's ¹	Hematoxylin; acid aniline fuchsin (Guyer, 1947; Lillie, 1948)
	Fresh	Janus Green B
Pigments:		
Melanin	Formalin	Bodian (Dublin, 1943)
Hemosiderin (Fe ⁺⁺⁺)	Formalin	Perl's test (Lillie, 1948; Gomori, 1952)
Fe ⁺⁺	Formalin	Ferricyanide test (Glick, 1949)
Bilirubin	Formalin	Stein test (Glick, 1949)
Enzymes:		
Alkaline phosphatase	Cold acetone + 95% alcohol	Gomori (1952)
Acid phosphatase	Cold acetone	Weinreb (1955)
Lipase	Cold acetone	Gomori (1946)
Peroxidase	Formalin	McJunkin method (Glick, 1949)
DOPA oxidase	Formalin	Laidlaw (Glick, 1949)
Ascorbic acid	Acidified silver nitrate	Gomori (1952)

¹ Positive reactions.² Weakly positive; remainder negative.³ Control: acetone (removes lipid)—slight reaction; ether-alcohol (removes phospholipid)—slight reaction; acetone + ether-alcohol—no reaction.

odic acid-Schiff (PAS) test (Lillie, 1948), acid mucopolysaccharides (a.MPS) according to Rinehart and Abul-Haj (1951), and sulfated acid mucopolysaccharides using 0.1 percent toluidin blue in citrate buffer at pH 3.6. Control slides for mucopolysaccharides were pretreated with salivary enzymatic digestion and hyaluronidase (Alidase, G. D. Searle and Co.); neither treatment resulted in loss of stainable material. Incubation in cold 10 percent perchloric acid for 18 hours to remove ribonucleic acid, did not cause loss of metachromasia. The same regions were tested for alkaline phosphatase (Alk. P) activity (Gomori, 1952), in order to correlate the type of mucopolysaccharide present with enzyme activity and possible absorptive function (Table II).

In addition, the reticular connective tissue and endothelium of blood vessels and lymphatics in all organs showed sites of phosphatase activity. The stratum compactum, like the collagenic fibers, was negative for this enzyme.

TABLE II
DISTRIBUTION OF MUCOPOLYSACCHARIDES AND
SITES OF ALKALINE PHOSPHATASE ACTIVITY

Organ	n.MPS (PAS)	a.MPS	Sul- fated a.MPS	Alk. P.
Swim bladder:				
Mucus of columnar cells.....	+	+	+	-
Esophagus:				
Upper:				
Stratified epi- thelium.....	+	-	-	+
Intermediate:				
Columnar cells....	+	-	-	+
Mucus cells.....	+	+	+	-
Lower:				
Mucus of columnar cells.....	+	+	-	-
Cardiac stomach:				
Mucus of columnar cells.....	+	+	-	-
Pyloric stomach:				
Mucus of columnar cells.....	+	+	+	-
Intestines and caeca:				
Striated border....	+	-	-	+
Goblet cells.....	+	+	+	-

The mucopolysaccharides of the digestive tract and swim bladder are of two types, acid (sulfated or not) and neutral (or basic). The sites of alkaline phosphatase activity are in the regions with the neutral mucopolysaccharides. This finding is in agreement with that of Moog and Wenger (1952). The intensity of staining in the mucopolysaccharide and enzyme tests appears to be comparable, which is indicative of comparable concentrations of these materials. Both tests were very strong in the striated borders of the intestine and caeca. To a lesser extent, this was also true of the striated borders present in the upper and intermediate regions of the esophagus. In the esophagus the enzyme was also present in the cytoplasm in a lesser concentration. The striated borders of the intestines and caeca are believed to be areas of active absorption, and it is probable that the borders of the cuboidal and columnar cells of the esophagus are also concerned with this function. In contrast, the lower esophagus, stomach, and goblet cells of the intestine and caeca which are secreting acid mucopolysaccharides are devoid of sites of phosphatase activity. The varying pH's of the digestive tract mucins may be associated with the activities of the enzymes present, the neutral or basic regions being suitable for alkaline phosphatase activity, as suggested by Moog and Wenger (1952).

SUMMARY

The histology of the digestive tract of the rainbow trout is similar to that of the king salmon. The structure of the tissue layers of the esophagus, stomach, pyloric valve, intestine and caeca, as well as the swim bladder and duct, is described. A brief description of the liver and pancreas is included. Special attention has been given the unique structures of the pyloric valve and the sphincter surrounding the swim bladder duct. Phagocytic activity in the digestive tract and related organs is described following intraperitoneal injections of Thorotrast. The granule cells have been studied by means of histochemical tests and their chemical structure determined on the basis of these tests and the effects of various fixatives. The presence of mucopolysaccharides and sites of alkaline phosphatase activity were determined in the entire digestive tract and swim bladder.

ACKNOWLEDGMENTS
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ACKNOWLEDGMENTS.—The authors are indebted to Miss Patricia Teasdale for her technical assistance, to Mr. Ross Norris for the illustration work, and to Dr. Stanley Weinreb for the preparation of the photomicrographs.

This work has been supported by funds made available by the Research Committee of the Graduate School and the Wisconsin Conservation Department.

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Length-Weight Relationship in Migrating Fry of Pink Salmon (*Oncorhynchus gorbuscha*) in Sashin Creek, Little Port Walter, Alaska

BERNARD EINAR SKUD

THE spawning migration of pink salmon, *Oncorhynchus gorbuscha* (Walbaum), at Sashin Creek, Little Port Walter, Alaska occurs during the months of August and September. Length measurements show that adult females passing through the counting weir early in the fall are larger than females in the later portion of the run. The seaward migration of the fry takes place during the months of March, April and May. If, as biologists believe, early and late migrating fry are the progeny of early and late adults, respectively, a similar trend in size might be expected. The purpose of this research is to determine whether earlier fry migrants are larger than the late migrants, and thus have a better chance of survival.

In 1941 and 1942 at Sashin Creek the numbers of migrating fry were so great that it was not feasible to count each individual. Instead the number of pints of migrants was counted and an actual count of the number of fry per pint was made on various days during the season. Although there was a random fluctuation in these numbers per pint, a positive correlation was found between the numbers and the time of migration. There is a general increase in the number of fry per pint which indicates a decrease in size as the migration progresses (Tables I and II). Using the 20th sampling day as an arbitrary mid-point, the mean numbers of fry per pint in the early and late portions of each season were compared. ("Students" t for 1941 = 1.60, 14 d.f., $P = 0.14$; 1942 = 3.29, 11 d.f., $P < 0.01$.)

In order to make a detailed comparison of

individuals or groups of individuals in a specific run of fry migrants, use is made of the length-weight relationship $W = aL^n$, where W is the weight in grams, L the fork length in mm., and a and n are empirically determined constants (Lagler, 1952).

The values of $\log a$ and n were determined for a time-scaled series of samples in 1942, 1943, 1944 and 1948, the only years when fry sampling included individual length and weight measurements. The samples were taken from the downstream weir at the mouth of Sashin Creek. Sampling periods were spaced throughout the downstream migration so that samples provided data on successively later migrants. The values of $\log a$ and n for each sampling period are presented in Table III.

To validate the use of an analysis of covariance, tests were applied to determine normality and constant variance of $\log W$. These tests were applied only to the data for 1942, when samples were large enough to show significant results. In the majority of cases, $\log W$ was normally distributed for each length class and the variance was constant from length to length. Since the general assumptions of analysis of covariance were fulfilled, the usual test was applied and the slopes of the lines were found to be significantly different at the 5 percent level.

$\log a$ and n generally increase in value as the seaward migration progresses (Table III). To measure the probable occurrence of the trend, use is made of the time-series significance tests based on signs of differences and the table

COMPARISONS
AND SIGNIFICANCE
TESTS

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TABLE I

COMPARISON OF THE NUMBER OF FRY PER PINT
AND SUCCESSIVE SAMPLING DAYS AT SASHIN
CREEK IN 1941 (COEFFICIENT OF
CORRELATION = +.66)

Date	Number of days from first sampling	Number of fry per pint
March 17	1	971
24	8	973
27	11	1650
30	14	1607
31	15	1742
April 2	17	1741
2	17	1808
3	18	1670
5	20	1798
7	22	1559
9	24	1730
9	24	1720
12	27	1681
18	33	1807
20	35	1674
24	39	1800

of probability presented by Moore and Wallis (1943). The probabilities of the directional movement of $\log a$ and n for each year are presented in Table IV.

Though only three of the independent tests are significant, the aggregate suggests that the probabilities on the whole are lower than would have been obtained by chance. Using Fisher's

TABLE II

COMPARISON OF THE NUMBER OF FRY PER PINT
AND SUCCESSIVE SAMPLING DAYS AT SASHIN
CREEK IN 1942 (COEFFICIENT OF
CORRELATION = +.81)

Date	Number of days from first sampling	Number of fry per pint
April 7	1	1441
8	2	1481
9	3	1554
19	13	1594
21	15	1473
22	16	1562
23	17	1521
28	22	1562
29	23	1557
May 6	30	1678
7	31	1607
13	37	1625
14	38	1657

TABLE III

VALUES OF $\log a$ AND n OF SUCCESSIVE FRY
SAMPLES FROM SASHIN CREEK, LITTLE PORT
WALTER

Year	Date	Number in sample	$\log a$	n
1942	March 14	50	-2.296	1.118
	March 23-24	110	-2.704	1.392
	March 25-27	100	-3.436	1.879
	April 2-3	110	-3.746	2.080
	April 9-10	120	-4.125	2.328
	April 16-17	120	-4.501	2.574
	April 23-24	120	-4.309	2.445
	April 30,	120	-4.524	2.576
	May 1			
	May 7-8	120	-4.911	2.835
	May 14-15	120	-4.475	2.536
1943	April 29,	100	-2.851	1.495
	May 3			
	May 6-10	100	-3.115	1.991
	May 17-20	100	-3.716	2.062
	May 24-31	100	-3.891	2.173
	June 3-7	100	-3.540	1.935
1944	March 26-27	96	-3.610	2.007
	April 2-3	94	-4.417	2.535
	April 9-10	100	-3.173	1.703
	April 16-17	100	-3.482	1.899
	April 25-26	100	-3.484	1.897
	May 1-2	100	-3.518	1.924
	May 8-9	100	-4.218	2.382
	May 15-16	100	-4.249	2.390
1948	May 4	50	-5.451	3.186
	May 10	50	-5.301	3.074
	May 17	50	-3.411	1.813
	May 24	100	-4.046	2.243
	May 31	50	-4.455	2.506

TABLE IV

PROBABILITY OF TREND OF $\log a$ AND n AS DETERMINED FROM TIME SERIES SIGNIFICANCE TESTS
BASED ON SIGNS OF DIFFERENCES (MOORE
AND WALLIS, 1943)

Year	P of $\log a$	P of n	Number of samples
1942	.026	.026	10
1943	.450	.450	5
1944	.012	.225	8
1948	1.000	1.000	5

TABLE V
ESTIMATED LOG OF THE WEIGHT AT DIFFERENT LENGTHS IN 1942 AT SASHIN CREEK, ALASKA*

Date	Length in millimeters								
	27	28	29	30	31	32	33	34	35
Mar. 14	-.695	-.677	-.660	-.644	-.628	-.612	-.597	...	...
Mar. 23-24	-.647	-.677	-.608	-.590	-.572	...
Mar. 25-27	-.688	-.661	-.634	-.608	-.583	-.559	...
Apr. 2-3	-.703	-.673	-.643	-.614	-.587	-.560	-.533
Apr. 9-10	-.720	-.685	-.652	-.620	-.589	-.559	-.530
Apr. 16-17	...	-.776	-.737	-.699	-.662	-.627	-.592	-.559	-.527
Apr. 23-24	...	-.770	-.733	-.697	-.662	-.628	-.596	-.564	-.533
Apr. 30, May 1	-.757	-.719	-.682	-.647	-.612	-.579	-.546
May 7-8	-.765	-.723	-.683	-.644	-.606	-.569	-.533
May 14-15	...	-.806	-.767	-.730	-.693	-.659	-.625	-.592	-.560

* Log W is presented only for the lengths within the range for a given sample.

(1944) method for combining probabilities from tests of significance, the probability of the combined values in Table IV is found to be .020.

Estimates of the logarithm of the weight at the different lengths in each sample are de-

termined from:

$$n (\log L) + \log a = \text{estimated log } W$$

Table V shows the estimate log W for the samples taken in 1942. The consistent negative increase of log W for each length class indicates a decrease in weight as the season progresses.

A regression diagram combining the data on a monthly basis and using the empirical weights of each individual (Fig. 1) exemplifies the phenomenon that, for a given length class, the weight of early migrants is greater than the weight of late migrants. Thus, fry migrating seaward in the spring of the year do exhibit the same trend in size as adults during their spawning migration at Sashin Creek.

The importance of the size phenomenon to the early life history of the species warrants further discussion. Neave (1948) pointed out that factors which reduce the growth rate can be expected to have an unfavorable effect on survival, and Brett (1952) showed that the mortality of young salmon due to low temperatures was greater among smaller individuals. At Sashin Creek, then, chances of survival may be more favorable for the early, larger fry than for the later and smaller migrants.

Possible factors which produce the length-weight difference between early and late fry migrants fall in three general categories—environmental, physiological and genetic. The listing which follows is not considered to be exhaustive.

I. Environmental.

1. Earlier egg deposition may be more favorably synchronized with climatological

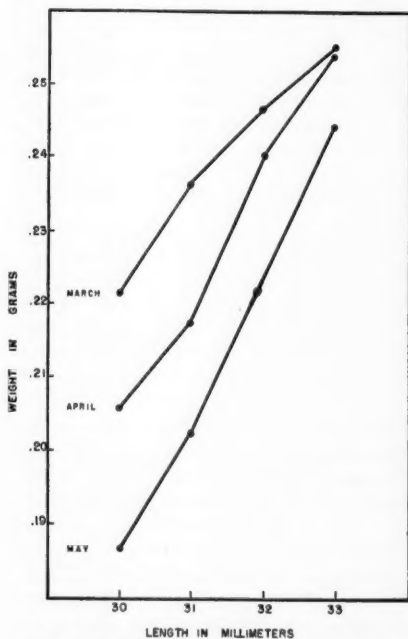


Fig. 1. Comparison of the averages of the empirical weights for given lengths during March, April and May of the 1942 migration at Sashin Creek.

changes during incubation. Low temperatures in the fall may have an adverse effect on eggs from a late deposition, whereas, eggs of earlier deposition in a more advanced stage of development may be less susceptible to such conditions.

2. At Sashin Creek, early adults usually utilize the upper reaches of the spawning area and the resulting progeny have a greater distance of stream to travel before reaching the sampling station. These individuals are exposed to more predators than are fry hatched in the lower reaches of the stream, and the existence of selective predation could result in a biased size distribution at the counting station.
3. Reports suggest that fry do not feed in fresh water, but this theory has not been proven and the possibility of feeding differences between the fry should be entertained.

II. Physiological.

1. Differences of nutritive values within the eggs of early and late individuals may exist, and similarly, the rate of yolk absorption may differ.
2. A shorter incubation period could well be responsible for the more favorable growth in early migrants. Increased metabolism may institute more complete utilization of available nutrients.
3. The later migrants may remain in the stream following emergence for a longer period than the early migrants, and this could be adverse to their best growth.

III. Genetic.

1. Data gathered from Sashin Creek show that in six out of seven years the early spawners were larger than late spawners. The resulting progeny may reflect this adult condition.

Knowledge of pink salmon biology is limited, and little factual evidence can be presented as

to the effects of physiological factors on size. Similarly, genetic studies of pink salmon have received little or no attention. The environmental factors, on the other hand, have been under intensive study and afford a basis of plausible factors which might produce size differences. In the light of present information, the author is inclined to credit early egg deposition, coupled with favorable thermal conditions, as the factor predominantly affecting size differences between early and late fry migrants.

I am indebted to Douglas G. Chapman of the University of Washington for statistical counsel.

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Heat Transfer in the Goldfish, *Carassius auratus*

R. E. DAVIS

THERMAL interchange between fish and water of rapidly changing temperature was studied. It was shown that living fish adjusted to changing temperatures considerably faster than dead fish. It was also apparent that the circulatory system and the gills play an important role in the transfer and distribution of heat.

In the 25-gallon aquarium a water volume of 15 (± 2) gallons was maintained. Water temperatures were changed by replacing the water in the tank through a mixing valve coming from hot and cold city water outlets and siphoning water out at the same rate of flow. A trough

was placed in the center of the aquarium; at one end it housed a pump which drove the water towards the fish and then out into the tank for re-circulation, and at the other end the experimental animal was placed in a wire cage in which it was securely held (Fig. 1).

Copper-constantan thermocouples (Leeds and Northrup duplex 30 ga. wire) were used to sense the temperatures in the fish's body cavity and in the water simultaneously. The thermocouple for measuring body temperatures was soldered into the tip of a syringe needle so that it could easily be inserted through the body

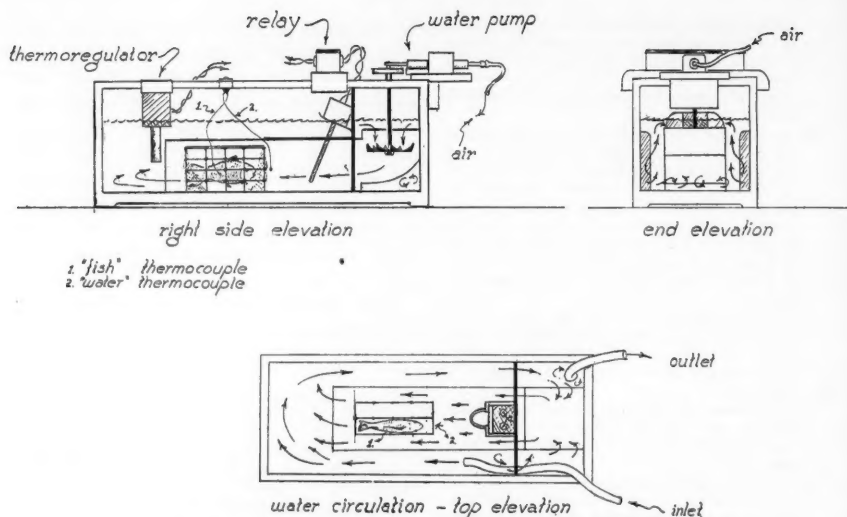


Fig. 1. Experimental tank for study of heat transfer in goldfish.

wall (Fig. 2). A Leeds Northrup potentiometer with a standard reference for adjustments in conjunction with a reflecting galvanometer was used as the indicating unit.

Because goldfish are hardy and easy to keep, they were selected as the experimental animals. Two weight groups of fish were used: one between 80 and 90 grams averaging 120 mm. in standard length, and another weighing about 160 grams and averaging 178 mm. in standard length. The former fish were between 2 and 5 years of age, while the latter were over 5 years old.

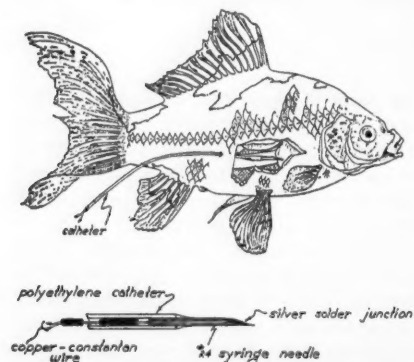


Fig. 2. The thermocouple used for measurement of body temperature and its location in the fish.

The experiments essentially consisted in subjecting a fish to two series of tests. The only difference between these two series was that the fish was alive in one and dead in the other. In each series, the fish were subjected to the following water temperature changes (in °C): Test No. 1, 25° to 30°; Test No. 2, 30° to 16°; and Test No. 3, 16° to 14°. The tests on the dead fish were performed after the fish had been killed by exposure to 40°C at the end of Test No. 3.

A second experiment was devised to illustrate the role of the gills and hence of the flowing blood in adjusting the temperature of the body to changes in water temperature. Here, only the head slightly distal to the gill covers was subjected to changes in water temperature, while the temperature of the water flowing over the rest of the body was kept constant. Available time only permitted me to treat this as an exploratory experiment which did, however, suggest the need for further investigation.

These temperature changes on the anterior half of the fish were achieved in the following way: A goldfish was supported on an inclined tray; its trunk was insulated with cheesecloth and aluminum foil. Cooling by evaporation was minimized by bathing the space beneath the metal insulation with water at 25°C. Water

from the fish's mouth that came away from the water level. The thermocouple was observed of the temperature to 25°C. The water temperature change. The true temperature was also recorded with the 25°C. fish.

It was subjected to its gills. The experiment was expected to be merged with the dead fish. The temperature was through.

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Both closely related to the latter part of the fish after the of the fish.

from the mixing valve was fed through the fish's mouth with a rubber hose. The water that came through the foil covers was drained away from the head. The temperatures of the water bathing the gills was recorded with a thermo-couple. Records of body temperature were obtained as indicated before. Prior to each of the tests, the body temperature was adjusted to 25°C. At the beginning of the experiment, the water entering the mouth was held at 25°C. The temperature of this water was gradually changed to 16°C., while the water flowing over the trunk was held at 25°C. The test was completed when the temperature of the body cavity also reached 16°C. The fish was then killed with hot water, its body again adjusted to 25°C., and the tests were repeated on the dead fish.

It was found that the living fish, which was subjected to a change of temperature only over its gills, adjusted a little more slowly than might be expected if the entire fish had been submerged. The same procedure repeated on the dead fish, however, showed that it took about twice as long to reach adjustment of body temperature as when blood has been circulating through the gills and from there to the body.

Among the properties affecting the capacity of the fish's body to conduct heat are: the amount of surface area across which heat transfer can occur between fish and water, the thickness of the tissue and its thermal conductivity, the intensity of metabolic activity, and the capacity of the circulatory system for heat distribution.

Body temperature always corresponded closely to environmental temperature when the latter was held constant. Therefore, metabolic heat production was probably unimportant in these experiments. Table I shows that living fish always adjusted faster than the same fish after death, but it also suggests that body size of the animal involved has an important bearing on the rate of heat transfer. The smaller

TABLE I
COMPARISON IN HEAT TRANSFER BETWEEN LIVING
AND DEAD GOLDFISH*

Weight of fish in grams	Change in temperature		
	+15°C	-14°C	+24°C
	%	%	%
83	97	100	88
96	82	...	100
160	46	...	41

* When dead fish took twice the time of living fish to adjust to change in temperature, rate of heat transfer was assumed to have declined 100%.

fish adjusted faster than the larger, and this relationship between fish of different sizes did not vary substantially when they were treated at different temperature intervals, as represented by Tests 1, 2, and 3. In order to ascertain whether this contrast in relative efficiency of heat adjustment between larger and smaller fish also finds its explanation in the circulatory system, accurate comparison between fish of different sizes and ages should be made. Perhaps small fish have a greater cardiac output per unit of body weight, or perhaps they have a relatively greater gill surface to handle heat transfer than do large fish. It may be that the rate of metabolism decreases with age and that there would be less vascularization of the external layers of tissues. Thus there would be more insulation in larger (older) than in smaller (younger) fish. The need for further research on this phase of the problem is clearly indicated.

This paper summarizes thesis work done in partial fulfillment of the requirements for the degree of Master of Science in the School of Natural Resources (Department of Fisheries) of the University of Michigan in July, 1954. The original thesis is on file in the Library of the University of Michigan.

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Early Developmental Stages of the California Scorpionfish, *Scorpaena guttata*

GRACE L. ORTON

THE California scorpionfish, *Scorpaena guttata* Girard, spawns throughout the summer months in aquaria at Scripps Institution. Captive specimens have supplied material for studies on the eggs and early larval stages of this marine species by Barnhart (1932) and David (1939), as well as for the present paper. In the work reported here, the embryonic and prolarval stages are re-described in greater detail in an effort to simplify future comparison with the early pelagic stages of other scorpaenid fishes of the Pacific coast. The eggs and newly hatched larvae from Cortez Banks that Eigenmann (1892) tentatively identified as *Fierasfer dubius* are here referred to *Scorpaena* sp. In addition, the literature on early stages of several extra-limital forms of *Scorpaena* and of certain other fishes is discussed briefly, and the need for more extensive study of developmental characters of scorpaenid fishes is pointed out. The description of *S. guttata* is based on living specimens except where otherwise stated.

This paper is No. 777 in "Contributions from the Scripps Institution of Oceanography, New Series."

EGGS

The general appearance of the egg mass of *Scorpaena guttata* is well known from the descriptions by Barnhart and by David. The eggs are imbedded, each in a cell-like space, in a single layer in a thin gelatinous matrix that forms a hollow, bilobed balloon. The mass has a length of about 250 mm., and drifts at or near the surface until the eggs hatch. Individual eggs, freed from the gelatinous material, also float at the surface. When freshly spawned, both the matrix and the eggs are colorless, transparent, and very inconspicuous in the water, but the matrix ultimately acquires a somewhat milky appearance.

The recently spawned egg mass is a remarkably elastic unit. In microscopic examination with oblique light, fresh pieces show series of very minute surface striations which change in shape and spacing when the matrix is stretched or pulled, and are probably associated with the

elastic structure of the material. The texture of the matrix changes considerably during incubation. At three days, the tiny surface striations are no longer visible, and the material is softened and invaded throughout by microorganisms, which form minute whitish flecks. On the surface, these microorganisms concentrate along sutures that outline polygonal blocks of irregular size and shape, one enclosing the position of each egg (Fig. 1). These structural details, not previously described for this species, suggest that the matrix is at least partly compounded from material secreted around each individual egg. Sparta (1928) found a similar block-like construction to characterize a gelatinous pelagic egg mass of an unidentified Mediterranean scorpaenid.

The individual egg of *Scorpaena guttata* is slightly ovoid and has a long diameter of about 1.2 mm. The thin capsule and the yolk are transparent, colorless, and non-textured. There are no oil globules, and there is no visible perivitelline space until the embryo is sufficiently developed to indent the surface of the yolk away from the capsule.

EMBRYONIC DEVELOPMENT

Some of the principal events in the embryology of *Scorpaena guttata* were stated briefly by David (1939). She found that freshly spawned eggs were always in "advanced blastoderm" stage when taken from the tanks in the morning, and she estimated that spawning occurs about midnight. Twenty-two hours after this estimated time of fertilization, the blastoderm enclosed about four-fifths of the yolk and an embryonic axis with seven somites had formed; at 34 hours the blastopore had apparently closed, there were 14 somites, the eyes, lenses, and ear capsules were formed, and Kupffer's vesicle was present, but pigment had not yet appeared. Some of the embryos, she recorded, hatched at an estimated age of about 58 hours, but "most hatch during the following night."

In the material I have studied, freshly spawned eggs taken from the tanks early in

the morning have been in blastular stages, essentially as reported by David. The blastular cap covers one end of the yolk and has a minutely granular texture. Around its periphery the cells are larger and very distinct. On the yolk surface, a short distance out from the defined blastular margin, there is a conspicuous zone of linear, granular objects that appear to be large cells (periblast nuclei?) that are migrating outward.

Embryos in later stages of germ ring growth and blastopore closure show progressive advances in differentiation of the embryonic axis and of its associated structures. The brain is slightly widened and the optic capsules are defined, but the lenses are not yet visible. An embryo with a very large blastopore appeared to lack defined somites; one with a small blastopore had about six somites and a distinct Kupffer's vesicle. Embryos with the blastopore closed but with a scar-like area still marking its position have nine or ten somites. In these embryos, the body axis extends nearly the full length of the yolk sac, and ear capsules are distinct. This stage is developmentally younger than David's 34-hour embryo. After closure of the blastopore, the surface of the yolk sac has a slightly pebbled texture which apparently results from the presence of enlarged cells scattered in the skin. The yolk itself remains homogeneous and non-textured. Kupffer's vesicle is often complex in this species, as noted by David. In some embryos it consists of a cluster of seven or more bubble-like expansions, with one larger than the rest.

On the morning after closure of the blastopore (age about 36 hours), the body is well defined and slight movements are occasionally visible. There are apparently about 23 somites (about 12 on the body and about 11 on the short tail). The lenses have formed and the

small ear capsules are better defined. The heart has formed, in line with the posterior end of the midbrain, and it contracts occasionally. The median finfolds are distinct, the dorsal fold visible at least as far forward as the midbrain. The perivitelline space is evident anteriorly and caudally, where head and tail depress the surface of the yolk sac away from the capsule. A few hours after this stage, the tail has lengthened distinctly and has a greater lateral curvature, and the dorsal finfold is better defined anteriorly, where it now rises well above the underlying tissues.

The next morning (age about 56 hours, in David's method of timing) some of the eggs hatch if they are shaken. At this stage (Fig. 2) the embryo has well-developed median finfolds; anteriorly, the dorsal finfold has inflated, bag-like contours and does not form a median edge. Reduction of the yolk has begun, but there has not been a corresponding shrinkage of the skin overlying it; hence the peculiar ballooned appearance of the yolk sac. The heartbeat is fairly regular at this stage. The tail curves laterally, but is too short to reach the head. The anal tube adjoins the posterior surface of the yolk sac. Some embryos, apparently normal, remain encapsulated for as long as 24 hours after most of the individuals have emerged. The actual process of hatching has not been observed, and it is not certain how these small, delicate larvae escape from the thin but extremely viscid matrix in which the eggs are imbedded. Under laboratory conditions, the matrix becomes heavily infested with microorganisms and partly disintegrates before hatching occurs.

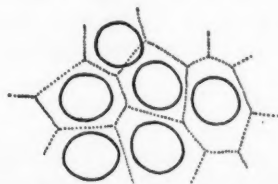


Fig. 1. Part of egg mass of *S. guttata*, diagrammed to show polygonal surface texture of matrix.

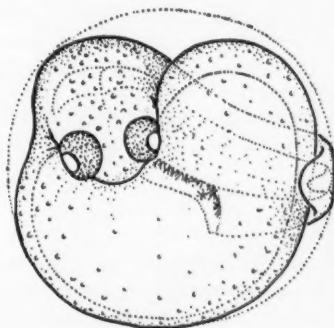


Fig. 2. Advanced embryo of *S. guttata*.

THE PROLARVAL STAGE

As defined by Hubbs (1943), the prolarval stage of fishes comprises the period in larval development from hatching to the complete disappearance of the yolk sac. The newly hatched prolarva of *Scorpaena guttata* (Fig. 3) was described briefly by both Barnhart (1932) and David (1939), and was figured by the former. Larvae that hatch at the average time (about three days) have a total length of about 1.9 to 2.0 mm. The larva is transparent, and is moderately stout-bodied and short-tailed. The transparent, colorless yolk sac is large and ovoid, but usually extends forward no farther than the posterior edge of the eye. The gut is well developed, straight, rather flat except posteriorly; the hindgut is curved downward, and the anus is slightly posterior to the end of the yolk sac. The head contours are still very embryonic; the eyes are well developed, but there are no visible jaws. The tail is well developed, and is slightly shorter than the head and body. The tail tip is straight and simple, with no indication of hypural or ray development. The pectoral finbuds are small and inconspicuous; there is no trace of pelvic buds or of median finrays. The skin over all surfaces is much inflated and bag-like; it closely adjoins the sub-surface structures at only a few points, chiefly at the tip of the snout and in the pectoral region. The dorsal finfold has a broad transverse curvature anteriorly, and bears a median longitudinal zone of somewhat enlarged cells; only along the distal part of the tail is the finfold compressed to form a distinct edge. "Ballooning" of the skin is especially conspicuous around the yolk sac. The entire surface of the skin is slightly roughened by minute, widely spaced granulations. After preservation in formalin, the wide mid-dorsal surface of the dorsal finfold acquires the hexagonally patterned texture figured by both Barnhart and David. Preservation apparently emphasizes the outlines of the en-

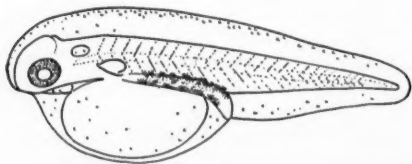


Fig. 3. Recently hatched larva of *S. guttata*.

larged skin cells in this area. The eyes of the recently hatched larva are dark gray. There is a double row of finely dendritic melanophores along the top of the gut, with branching processes that extend upward along the bases of the somites and downward over the sides of the gut; there are a few melanophores along the lower surfaces of the gut.

The macroscopic appearance of the larvae at this stage was aptly described by Eigenmann (1892: 173) as "sets of two black dots and a black streak." His drawings, though diagrammatic, show the pigmentation of the advanced embryo and hatching larva of *Scorpaena* more accurately than does Barnhart's figure of the same stage.

On the following day (about 72 hours after estimated spawning time) most of the larvae have hatched. The reduced yolk sac varies somewhat in size and shape, and is placed well back along the gut. The rather posterior position of the yolk sac and the extension of the dorsal finfold forward onto the front of the head combine to give the head a somewhat overbalanced appearance at this stage (Fig. 4). The pectorals are larger and are edged with a thin finfold. The head contours are considerably modified, for the midbrain now bulges upward and forward and the jaw and branchial rudiments form a prominent swelling on the lower surface of the head. The somites are difficult to count, but appear to number $10 + 14 = 24$ (the adult has 24 vertebrae; Clothier, 1950). The eyes are black with a few iridescent greenish flecks, and the melanophores on the gut are more abundant and cover the adjacent surfaces of the somites and the yolk sac more extensively. Some of the larvae now have a few very small melanophores along the midventral edge of the tail.

Three days later (four days after average hatching time) the yolk appears to be nearly or entirely gone, and the gut is much larger. The jaws are well developed and functional, and the head is proportionally much larger than

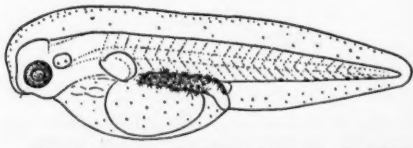


Fig. 4. Larva of *S. guttata* about one day after hatching.



Fig. 5. hatching.

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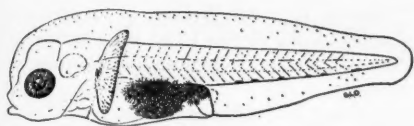


Fig. 5. Larva of *S. guttata* about four days after hatching.

in earlier stages (Fig. 5). The median finfolds and the skin over the body are still bag-like except on the posterior part of the tail where the finfolds form thin, compressed edges. Around the eyes and the jaw region the skin is closely attached to the subdermal tissues. The inflated skin perhaps aids in flotation. The median finfolds are still simple, non-rayed. The very large, fan-shaped pectoral fins are now important in locomotion. They beat strongly with appropriate action for forward swimming, backing, and turning, and when at rest they are held stiffly at nearly a right angle to the body. The larva is still transparent, and its basic pigmentation is little changed. The jet black eyes have flecks of iridescent bronze pigment. The posterior half of the body cavity has become more densely covered with melanophores, and a few small ones have appeared internally in the region of the pectoral girdle. The pectoral fins are edged with from one to several irregularly defined rows of very small melanophores. Some of the larvae have a large stellate melanophore on the base of the pectoral. The row of small black cells along the mid-ventral edge of the tail persists without apparent change.

The larvae seem to be quite hardy, even in small, crowded containers; but thus far all efforts to induce them to feed have failed, and it has not been possible to keep them alive in the laboratory for much longer than this stage.

COMPARISONS

The eggs, embryos, and early larvae of *Scorpaena guttata* are of striking appearance, and are easily distinguished from described stages of other fishes of the California coast; but it should be emphasized that the life histories of the marine fishes of this region are still very inadequately known. The California scorpaenid fauna also includes two species of *Sebastolobus* and about 50 forms of the complex genus *Sebastodes*. So far as known, the species

of *Sebastodes* are live-bearing and produce large "litters" of very small larvae. The few of these larvae that have been described, and those that I have seen, show a close group resemblance to *Scorpaena* in general morphological characters, but too few of them are known to justify detailed comparisons at present. Apparently nothing has been published on the reproduction of *Sebastolobus* or on its early developmental stages. Detailed comparative studies on the development of the Pacific coast scorpaenids are much needed, both for taxonomic purposes and for increased knowledge of the ecology of these desirable food and sport fishes.

Little has been published on early stages of extra-limital species of *Scorpaena* except those in the Mediterranean, although the genus has a nearly worldwide distribution in coastal waters of tropical and temperate seas. Early stages of *Scorpaena porcus* Linnaeus were described by Raffaele (1888), Fage (1918), and Sparta (1941a); of *S. scrofa* Linnaeus by Raffaele (*op. cit.*), Fage (*op. cit.*), and Sparta (1941b); of *S. ustulata* Lowe by Sparta (1941b); and of *Scorpaena (Helicolenus) dactyloptera* Delaroche by Fage (*op. cit.*) and Sparta (1941b). In addition, Sparta (1941a, b) discussed the possibility that the unidentified egg mass and larvae that he had described earlier (1928) might be referable to *S. dactyloptera*. The larvae that hatched from these eggs agreed closely in general characters and pigmentation with the smallest larvae of a developmental series of *dactyloptera* collected in the Straits of Messina, but differed in having a higher somite count (27–29) than the 24 or 25 thought to be typical of *Scorpaena* (including *Helicolenus*), and the eggs possessed an oil globule, which is lacking in the few definitely known eggs of *Scorpaena*.

The references cited above record specific differences in details such as egg size and larval pigmentation, but these Mediterranean forms agree closely among themselves and with *Scorpaena guttata* in the type of egg mass and in the general morphology and pigmentation of the embryo and larva. So far as the life histories of these fishes are known, the general pattern of development is essentially the same in the Mediterranean as it is in California waters. The consistent group resemblance in basic characters between geographically remote

populations is more significant for studies in the developmental systematics of these fishes than are the relatively small specific differences. Similar examples of stability and predictability of basic developmental characters should be made more generally known to fish taxonomists, in order to stimulate wider use of (and greater willingness to trust) this rich source of data for systematic studies.

Egg masses with a loose, gelatinous texture are known in relatively few groups of fishes, but eggs of this type characterize several groups that have representatives along the Pacific North American coast. Several of the Atlantic pediculate fishes, including *Lophius* and *Histrio* [Pterophryne], are known to have large, flat, ribbon-like, pelagic egg masses (Gudger, 1937), and it seems likely that forms of the related *Antennarius* along the Pacific coast may be similarly characterized. Two Mediterranean cusk-eels of the blennioid family Ophidiidae, *Ophidium barbatum* and *O. vassalli*, are reported to have small pelagic egg clusters (Sparta 1929). It is possible that similar egg masses may characterize some of the cusk-eels of the Pacific coast, but individual pelagic eggs have been taken off La Jolla that hatch into larvae which are not essentially different from described ophidiid larvae (unpublished notes).

The eggs of the Mediterranean *Carapus acus*, described by Emery (1880) under the name *Fierasfer acus*, are deposited in small, ellipsoidal, gelatinous, floating masses with dimensions of about 83×40 mm. The individual egg has a slightly ovoid shape, with a long diameter of 0.9 mm., and there is a large oil globule. In the newly hatched prolarva a small knob-like structure breaks the outline of the dorsal finfold a little posterior to the middle of the trunk. Soon after hatching, this structure begins to enlarge, and within a few days it forms a long filamentous ray with a series of heavily pigmented leaf-like appendages. The entire ray becomes nearly as long as the larva.

It seems probable that the eggs which Eigenmann (1892) identified tentatively as *Fierasfer* [*Carapus*] *dubius* were, instead, a species of *Scorpaena*. The size of the transparent, jelly-like mass (about one-half pint), the arrangement of the eggs in a single layer, the structure and pigmentation of the advanced embryos and hatching larvae, and the absence of oil globules agree essentially with diagnostic characters of

Scorpaena. Eigenmann's figure of the prolarva (his pl. 16, fig. 8) was based on a somewhat distorted, preserved specimen, but it shows no indication of the developing dorsal filament of the carapad larva. The eggs were rather small (diameter only 0.8 mm.), and it seems possible that they were spawned by some other northward-ranging species of *Scorpaena* rather than by *S. guttata*. Scorpionfishes are definitely known to occur on Cortez Banks, but there appear to be no valid records of carapad fishes that far north. Thus far, I have found no published information on the eggs or young larvae of any of the carapad fishes of the eastern Pacific.

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Lampetra zanandreaei, a New Species of Lamprey from Northern Italy¹

VADIM D. VLADYKOV

THANKS to Dr. Giuseppe Zanandrea, Istituto di Anatomia Comparata della Università di Bologna, we received two well-preserved samples of Italian lampreys, one of which consists chiefly of transformed individuals and the other of ammocoetes. Careful study showed these specimens to be so different in comparison with *Lampetra planeri* (Bloch), obtained from various European countries, that I regard them as a distinct species. This new species is named in honor of Dr. G. Zanandrea, who made several interesting biometrical and biological studies of lampreys from northern Italy (Zanandrea, 1940a, 1940b, 1947, and 1951).

METHODS OF MEASUREMENTS AND COUNTS

In addition to those measurements used by Hubbs and Trautman (1937: 27-41) and by Vladyskov (1949: 10-29; 1950: 79-90), some new ones have been added. All measurements and counts are typically made on the left side of the specimen.

MEASUREMENTS.—For convenience, a brief explanation of the different abbreviations used throughout the text is given below:

Abbreviations	Explanations
a-C	The length of the tail, the distance between the posterior edge of the cloacal slit and the extremity of the caudal fin.
Br-a	The length of the trunk, the distance between the posterior edge of the last branchial opening and the anterior edge of the cloacal slit.
Br-Br	The length of the branchial region, from the front of the first gill opening to the posterior edge of the seventh opening.
d	The diameter or length of sucking-disc measured longitudinally, when disc is closed; the oral fimbriae being included.
d-Br	The prebranchial region, the distance from the anterior edge of the sucking-disc, in the case of transformed individuals, or the anterior edge of the upper lip, in the case of ammocoetes, to the anterior edge of the first branchial opening.
hD ₂	The maximum height of the second dorsal fin, measured along the highest fin ray.

O

The horizontal diameter of the eye. It should be noted that young, half-grown adults, have eyes proportionally larger than fully mature specimens.

TL

The total length measured from the most anterior tip of the oral fimbriae to the end of the caudal fin. It should be remembered that, due to shrinkage during the initial hardening in formalin, the length of preserved specimens is from 1% to 3% shorter than that of fresh individuals. It is important to note also that the length of fully grown lampreys progressively becomes smaller toward spawning time (Cotronei, 1924a, 1924b, 1926, 1927; Weissenberg, 1925, 1926; D'Ancona, 1930; Zanandrea, 1940a; Vladyskov and Roy, 1948; etc.).

Throughout the text, when the different body parts are mentioned, their values are not given in absolute figures, but in percentages of the total length of the specimen. In the case of the sucking-disc, its diameter was also expressed in percentage of the length of the branchial region.

COUNTS.—The number of myomeres (segments) is a very important taxonomic character, particularly for ammocoetes. Certain European authors (Cotronei, 1927; D'Ancona, 1930) add to the trunk myomeres those of the branchial region, as they count all preanal myomeres, situated between the cloaca and the eye. Thus, according to Cotronei (1927: 416), *L. planeri* from Italy has from 72 to 74 myomeres. The trunk myomeres of the specimens of *planeri* used in this study (Table VII) varied only from 58 to 65. As myomeres of the branchial region are not always readily distinguishable, and because they unnecessarily raise the total number of myomeres, it was not considered important to count them. We follow the practice of American authors (e.g., Hubbs and Trautman, 1937: 28) that is, only the trunk myomeres were counted between the last (7th) gill-opening and the anterior tip of the cloacal slit. It should be remembered that, on the average, there are 1 or 2 trunk myomeres less in ammocoetes than in transformed individuals of the same species. The myomeres are also more clearly distinguishable in ammocoetes than in adults.

¹ Contribution No. 45, Department of Fisheries, Quebec, Canada.

Another important taxonomic character of transformed specimens is in the dentition of the disc. The number of *cusps* of the *infraoral lamina* and the number of *denticles* of the *lingual laminae* are somewhat different in *planeri* and *zanandreae*. In studying the lingual laminae, the whole tongue was removed, treated with 1 percent KOH, cleared in glycerine, and studied under a microscope. We follow Hubbs and Trautman (1937: 32) in using the terms *transverse* instead of *anterior lingual lamina*, and *longitudinal* instead of *posterior lingual laminae*.

Lampetra zanandreae, sp. nov.

Pls. I-IV

DIAGNOSIS.—A species of *Lampetra* that differs from other European species of the genus by: (1) the low number of trunk myomeres, 54-60 in transformed individuals and 52-56 in ammocoetes; (2) body proportions; (3) dentition; and (4) pronounced dark pigmentation on the head and tail of its ammocoetes.

TYPES.—Holotype, a male 131 mm. in total length (Pl. I; No. 4, Table II), in the collections of the Provincial Department of Fisheries, Quebec, Canada. Two paratypes (No. 2, Table II; and No. 3, Table I) are deposited in the British Museum (Natural History), London, and the rest are kept in Quebec.

DESCRIPTION

The material of *L. zanandreae* at my disposal consists of 18 transformed individuals, 13 males and 6 females, as well as 2 ammocoetes, obtained by Dr. Zanandrea on April 19, 1953, in the Guà de Lonigo River (Vicenza); and 26

ammocoetes, collected by members of the University of Pavia, on April 29, 1954, in the Ticino River, one of the northern tributaries of the Po River. Thanks to several persons from different parts of Europe, I received many specimens of *L. planeri*. This makes possible a comparison between transformed individuals and ammocoetes of both *zanandreae* and *planeri*.

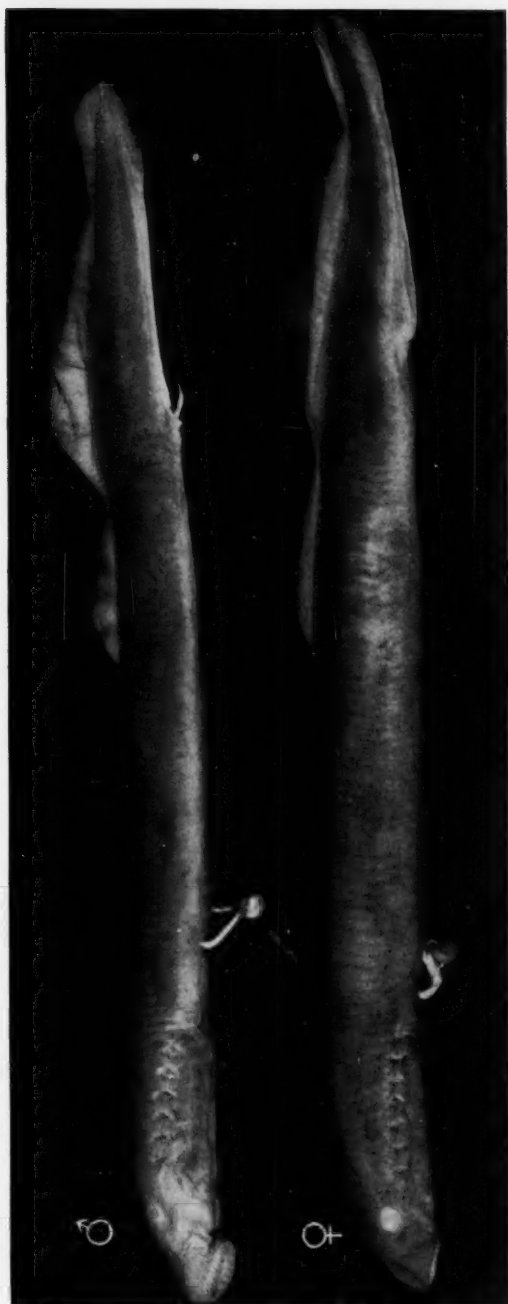
TRANSFORMED SPECIMENS

SIZE.—The length distribution of transformed specimens of *zanandreae* is given in Tables I-II. Six females averaged 133 mm.; and 13 males, 137.5 mm. These sizes are considerably larger than those for *planeri* from the Allier River (Culhat), France (Tables III-IV), where the average lengths for males and females were, respectively, 117 and 119 mm. This difference could be partially attributed to the fact that specimens from France were in a more advanced stage of maturity, and thus became shorter. In fact, according to Zanandrea (1951: 19), *planeri* from the Dese River, Italy, attains a length of 170 mm.

BODY PROPORTIONS.—A summary of body proportions is given in Table V. The most striking differences between the two species lie in the lengths of the tail and the branchial region, as well as in the size of the sucking-disc. *L. zanandreae* has a much shorter tail, the average length of which is 25.1 for females and 25.8 for males. For *planeri* the same measurements are, respectively, 26.5 and 28.3. The average diameter of the disc, expressed in percentage of the branchial region, is also considerably smaller in *zanandreae* than in *planeri*, being, respectively, 47.3 and 64.5 for females, and 55.3 and 78.9 for males. There is also a

TABLE I
BODY PROPORTIONS OF MATURE FEMALES OF *L. zanandreae*

No.	TL (mm)	d-B ₁ TL	B ₁ -B ₇ TL	B ₇ -a TL	a-C TL	hD ₁ TL	O TL	d TL	d B ₁ -B ₇
1	118	11.9	9.3	51.7	25.4	5.1	2.1	5.1	54.5
2	125	11.2	10.4	49.6	26.4	4.0	2.0	4.8	42.3
3	129	11.6	10.9	51.2	24.0	5.4	1.9	5.0	46.4
4	133	10.5	10.9	50.8	24.4	3.8	1.9	4.9	44.8
5	137	10.2	10.2	52.6	24.8	4.4	1.8	5.1	50.0
6	156	10.3	10.6	51.3	25.6	3.5	1.6	4.8	45.5
Ave.....	133	11.0	10.4	51.2	25.1	4.4	1.9	5.0	47.3



Mature specimens of *Lampetra zanandreu* from the River Guà de Lonigo (Vicenza), Italy. The length of the male, the holotype, is 131 mm., and the female is 137 mm. long.

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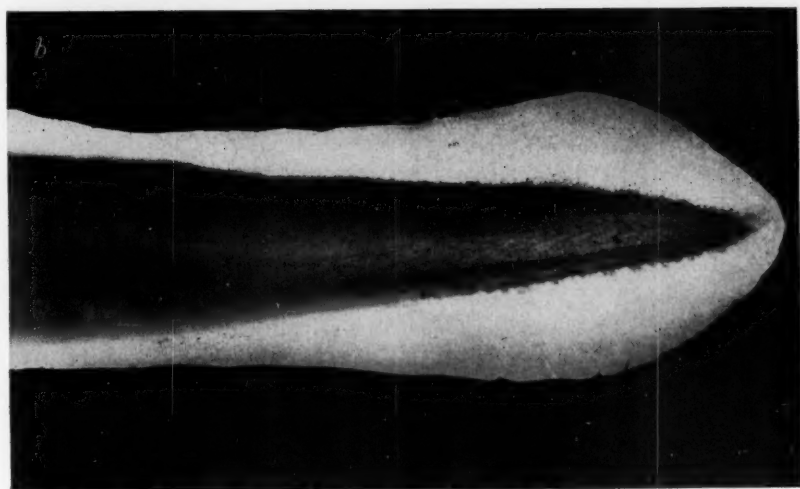
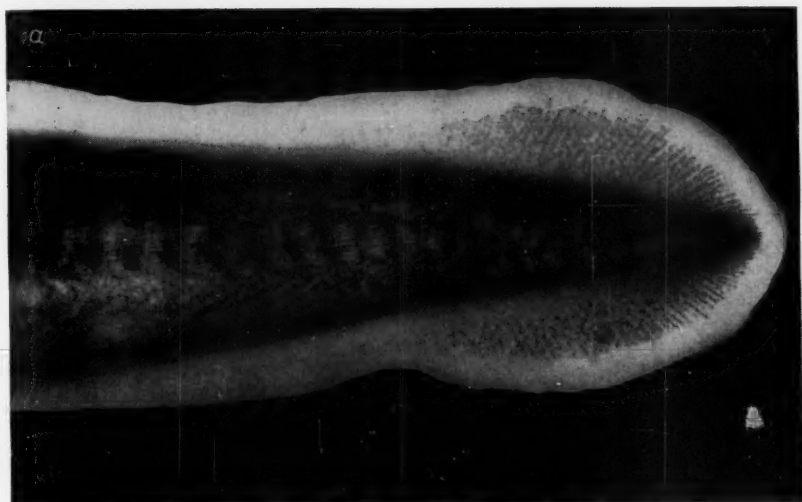
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Enlargements of heads of two species of ammocoetes. *a*—*Lampetra zanandreae*, 158 mm., from the River Ticino, Italy; *b*—*L. planeri*, 177 mm., from the River Allier, France.



Enlargements of tails of the same ammocoetes shown in Plate II. *a*—*Lampetra zanandreae*; *b*—*L. planeri*.



Ventral views of two species of ammocoetes. *a*—*Lampetra planeri*, 153 mm., from the River Allier, France; *b* and *c*—*L. zanandreae*, respectively 158 and 141 mm., from the River Ticino, Italy.

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TABLE II
BODY PROPORTIONS OF MATURE MALES OF *L. sanandrei*
Specimen No. 4 is the holotype

No.	TL (mm)	$\frac{d-B_1}{TL}$	$\frac{B_1-B_7}{TL}$	$\frac{B_7-a}{TL}$	$\frac{a-C}{TL}$	$\frac{hD_2}{TL}$	$\frac{O}{TL}$	$\frac{d}{TL}$	$\frac{d}{B_1-B_7}$
1	128	13.7	10.2	48.4	25.0	5.5	2.0	5.5	53.8
2	130	13.1	11.5	46.2	25.4	4.2	2.3	6.9	60.0
3	130	10.8	11.9	46.9	27.7	4.6	2.3	6.2	51.6
4	131	13.0	10.7	46.6	26.7	4.2	1.9	6.9	64.3
5	133	11.7	9.7	48.1	28.6	4.9	2.3	6.0	61.5
6	135	12.6	10.4	47.8	26.3	4.4	1.9	6.8	64.3
7	137	12.0	11.3	48.2	24.1	5.1	2.2	6.6	58.1
8	139	12.2	11.2	46.0	27.7	5.4	2.5	5.8	51.6
8	140	10.7	10.4	51.1	26.4	4.3	1.8	4.6	44.8
10	142	11.3	11.6	48.2	25.0	4.9	2.1	6.0	51.5
11	143	11.9	10.5	45.5	28.7	5.9	2.4	5.6	53.3
12	144	12.5	11.5	46.5	27.1	6.3	2.1	5.9	51.5
13	155	11.6	10.3	49.0	27.1	4.5	1.6	5.5	53.1
Ave.	137	12.9	10.9	47.6	25.8	4.9	2.1	6.0	55.3

TABLE III
BODY PROPORTIONS OF MATURE FEMALES OF *L. planeri* FROM THE RIVER ALLIER (CULHAT), FRANCE

No.	TL (mm)	$\frac{d-B_1}{TL}$	$\frac{B_1-B_7}{TL}$	$\frac{B_7-a}{TL}$	$\frac{a-C}{TL}$	$\frac{hD_2}{TL}$	$\frac{O}{TL}$	$\frac{d}{TL}$	$\frac{d}{B_1-B_7}$
1	106	11.3	7.5	53.3	25.5	5.7	2.8	5.2	68.8
2	110	11.4	9.5	50.5	26.4	5.0	2.7	5.5	57.1
3	111	11.7	9.5	50.9	27.0	5.0	2.7	5.4	57.1
4	116	11.2	9.1	50.9	25.4	6.0	2.6	5.6	61.9
5	116	11.2	7.8	50.0	25.4	5.2	2.6	5.2	66.7
6	119	11.3	9.2	49.6	26.1	5.0	2.9	5.5	63.6
7	119	10.9	8.4	46.6	26.9	4.6	2.5	5.5	65.0
8	122	11.5	8.6	49.2	28.7	5.7	2.5	5.7	65.4
9	128	10.9	9.0	50.0	25.8	4.9	2.7	5.5	60.9
10	129	10.9	7.8	48.8	28.3	4.7	2.3	5.4	80.0
11	133	11.3	9.0	51.1	26.3	4.5	2.3	5.6	62.5
Ave.	119	11.2	8.7	50.1	26.5	5.1	2.6	5.5	64.5

TABLE IV
BODY PROPORTIONS OF MATURE MALES OF *L. planeri* FROM THE RIVER ALLIER (CULHAT), FRANCE

No.	TL (mm)	$\frac{d-B_1}{TL}$	$\frac{B_1-B_7}{TL}$	$\frac{B_7-a}{TL}$	$\frac{a-C}{TL}$	$\frac{hD_2}{TL}$	$\frac{O}{TL}$	$\frac{d}{TL}$	$\frac{d}{B_1-B_7}$
1	107	12.6	8.4	44.4	28.0	6.1	2.8	7.0	83.3
2	111	12.2	8.1	46.8	27.5	5.4	2.7	6.8	83.3
3	120	11.7	7.9	49.2	29.2	5.0	2.9	6.7	84.2
4	121	12.4	9.9	50.8	31.4	5.4	2.5	7.0	70.8
5	127	11.0	8.7	50.4	25.6	4.7	2.8	6.3	72.7
Ave.	117	12.0	8.6	48.3	28.3	5.3	2.7	6.8	78.9

TABLE V

COMPARISON BETWEEN AVERAGE BODY PROPORTIONS OF MATURE SPECIMENS OF *L. zanandrei* AND *L. planeri*, BASED ON DATA PRESENTED IN TABLES I-IV

Species	Sex	N	TL (mm)	d-B ₁ TL	B ₁ -B ₇ TL	B ₇ -a TL	a-C TL	hD ₂ TL	O TL	d TL	d B ₁ -B ₇
<i>L. planeri</i>	♀ ♀	11	119.0	11.2	8.7	50.1	26.5	5.1	2.6	5.5	64.5
<i>L. zanandrei</i>	" "	6	133.0	11.0	10.4	51.2	25.1	4.4	1.9	5.0	47.3
<i>L. planeri</i>	♂ ♂	5	117.2	12.0	8.6	48.3	28.3	5.3	2.7	6.8	78.9
<i>L. zanandrei</i>	" "	13	137.5	12.9	10.9	47.6	25.8	4.9	2.1	6.0	55.3

difference between the two species in the diameter of the eye, which averages 2.6 and 2.7, respectively, for females and males of *planeri* and only 1.9 and 2.1 for *zanandrei* (Table V). At the same time, the branchial region is longer in *zanandrei*, averaging from 10.4 to 10.9, while in *planeri* it is from 8.6 to 8.7 percent only.

DENTITION.—The general pattern of dentition of *zanandrei* is similar to that of *planeri*: the supraoral cusps are well separated by a broad bridge, thus forming the supraoral lamina; on each side of the disc are 3 enlarged lateral teeth, the middle one typically tricuspid while the remaining are bicuspid; and the mandibular labials are lacking.² Thus, *zanandrei* possesses all typical characteristics of the genus *Lampetra*, as defined by Regan (1911).

In spite of a general resemblance, there exists a distinction between the two species in the number of infraoral cusps and denticles of the lingual laminae. The cusps of the infraoral lamina are less numerous in *zanandrei*, being on the average 6.5, while in *planeri* they average 7.1 (Table VI). Although 7 cusps are encountered most frequently in both species, the numbers 5 and 6 are absent in *planeri*, but found in 35 percent of *zanandrei*.

The denticles on the lingual laminae are very small in both species, particularly in *zanandrei*; they number fewer in this species than in *planeri*. In three specimens of *zanandrei* I counted on the transversal lamina only 5 (in two) and 7 (in one) denticles, the average being 5.7; while in *planeri* there were from 9 to 13 denticles, with an average of 10.6. A similar difference was found in the number of denticles on the longitudinal laminae: two

specimens of *zanandrei* had a total of 12 and 13 denticles for both laminae; in one specimen of *planeri* from France I counted a total number of 18 denticles.

TRUNK MYOMERES.—The most striking difference between *zanandrei* and *planeri* lies in the number of myomeres (Table VII). The transformed specimens of *zanandrei* have from 54 to 60 (ave. 56.3) trunk myomeres, and their ammocoetes have only 52 to 56 (ave. 53.6). Specimens of *planeri* from different European countries are characterized by more numerous myomeres, which vary from 60 to 65 (ave. 62.2) in transformed specimens and from 58 to 64 (ave. 60.7) in ammocoetes.

There is no overlap in the recorded myomere counts of ammocoetes of the two species, and only a slight overlap, at 60, in those for transformed specimens. The difference in averages between these two species amounts to 6 or 7 myomeres.

TABLE VI

VARIATION IN THE NUMBER OF CUSPS OF THE INFRAORAL LAMINA OF TWO SPECIES OF LAMPREYS

Country	N	Number of cusps					Average
		5	6	7	8	9	
<i>Lampetra zanandrei</i>							
Italy	17	3	3	10	1	..	6.5
<i>Lampetra planeri</i>							
France	16	..	..	16	..	..	7.0
England	16	..	..	13	2	1	7.2
Czechoslovakia	1	..	..	1	..	..	7.0
Sweden	13	..	..	11	2	..	7.1
Total for Europe	46	..	..	41	4	1	7.1

² Illustrations of tooth arrangements in different lampreys are given by Vladjov (1949).

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TABLE VII
THE NUMBER OF TRUNK MYOMERES OF TWO SPECIES OF LAMPREYS
a—ammocoetes; t—transformed individuals

Collecting details					Number of myomeres																	
Country	Locality	Date	TL range (mm)	Stage	N	52	53	54	55	56	57	58	59	60	61	62	63	64	65	Mean		
<i>Lampetra zanandrei</i>																						
Italy	River Ticino	IV-29-54	91-158	a	28	6	8	8	4	2	..	..	..	..	..	..	..	..	..	53.6
"	R. Guà de Lonigo	IV-19-53	118-156	t	19	..	..	4	5	1	3	4	..	2	..	..	..	..	..	56.3
<i>Lampetra planeri</i>																						
France	Chatillon	IX-20-50	79-101	a	4	..	..	..	..	..	..	..	1	2	..	1	..	..	..	60.3
"	River Auzon	V-25-52	45-177	a	12	..	..	..	..	..	..	1	4	2	4	1	..	..	..	60.0
"	" Morge	VI-7-52	46-164	a	13	..	..	..	..	..	..	1	2	5	3	1	..	1	..	60.4
"	" l'Allier	VI-10-52	106-133	t	16	..	..	..	..	..	..	..	..	4	4	4	3	1	..	61.6
"	" Loire	VI-20-53	107-137	a	12	..	..	..	..	..	..	..	1	2	4	1	4	..	..	61.4
Total for France					45-177	a	41	..	..	..	..	2	8	11	11	4	4	1	..	60.6
					106-133	t	16	..	..	..	..	..	..	4	4	4	3	1	..	61.6
England	New Forest, Hampshire	IX-47	93-118	a	6	..	..	..	..	..	..	1	3	1	1	..	..	..	..	60.3
"	New Forest, Hampshire	IV-50	112-137	t	12	..	..	..	..	..	..	..	..	1	3	2	3	1	2	62.5
"	River Chess	?	112-143	t	4	..	..	..	..	..	..	..	..	..	..	1	1	2	..	63.3
Total for England					93-118	a	6	..	..	..	..	1	3	1	1	..	..	..	..	60.3
					112-143	t	16	..	..	..	..	..	..	1	3	3	4	3	2	62.7
Czechoslovakia	River Labe	VII-51	72-147	a	11	..	..	..	..	..	..	2	2	3	3	1	..	..	..	60.9
Czechoslovakia	?	?	148	t	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	63.0
Sweden	Dalarne	VIII-8-48	32-82	a	5	..	..	..	..	..	..	3	..	..	1	..	1	..	..	60.6
"	River Delaven	X-14-51	89-117	a	21	..	..	..	..	..	2	3	6	2	4	1	3	..	..	60.9
"	" "	"	86-116	t	20	..	..	..	..	..	..	..	2	4	7	3	2	2	..	62.3
Total for Sweden					32-117	a	26	..	..	..	..	2	6	6	2	5	1	4	..	60.8
					86-116	t	20	..	..	..	..	..	..	2	4	7	3	2	2	62.3
Grand total for Europe					32-177	a	84	..	..	..	..	4	17	22	17	13	6	5	..	60.7
					86-148	t	53	..	..	..	..	..	..	7	11	14	11	6	4	62.2

COLORATION AND SEXUAL DIMORPHISM.—Due to preservation, lampreys lose the color displayed in life. The material of both *zanandrei* and *planeri* fixed in formalin has the same general coloration. The sides and back are greyish and the lower surface is whitish (probably pearly white in life). The two dorsal fins are yellowish. The caudal fin is yellowish, with grey pigmentation. The color of the disc teeth is pale yellowish in the 19 mature adults of *zanandrei*.

The rows of lateral-line organs in both species are of nearly the same pattern and remain uncolored throughout life. The absence of dark

pigmentation on the sense organs is typical of all species of lampreys possessing two distinct dorsal fins (Vladykov, 1949: 29).

At the onset of sexual ripening, irrespective of sex, the two dorsal fins approach one another and eventually meet (Pl. I). At the same time, the degeneration of the intestinal tract reaches a maximum. These phenomena are characteristic of all lamprey species, as was observed several years ago on certain European species by the present author (Vladykov, 1927).

The sexual dimorphism in *zanandrei* is very similar to that of *planeri*, as described by Zanandrea (1940a). The females of both species

in spawning condition are characterized by a well-developed "anal fin" (Pl. I). Their sucking-disc is considerably smaller than in males, the average diameters of which, in *planeri* and *zanandrei*, are, respectively, 5.5 and 5.0, while in males they are 6.8 and 6.0. On the other hand, the trunk in females is longer, being 50.1 for *planeri* and 51.2 for *zanandrei* (Table V).

Mature males of both species have a well-developed genital papilla (Pl. I). The second dorsal fin is much higher in males, and triangular in shape, while in females it is more rounded and lower. The diameters of the eye and of the sucking-disc are larger in males, but the trunk is shorter (Table V).

The curvature of the tail in adult individuals of the above species displays a sexual dimorphism similar to that described by Vladikov (1949: 30) for other lamprey species. The tail in breeding males bends downwards, but in females it typically turns upwards or sometimes remains straight (Pl. I).

TABLE VIII
BODY PROPORTIONS OF AMMOCOETES OF
L. zanandrei
Specimen No. 13 is the holotype

No.	TL (mm)	d-B ₁ TL	B ₁ -B ₇ TL	B ₇ -a TL	a-C TL
1	91	9.3	12.6	51.1	24.7
2	97	8.2	12.4	50.5	26.8
3	97	9.3	13.4	52.1	23.7
4	99	8.6	13.1	52.5	24.2
5	99	9.1	13.1	50.5	26.3
6	103	8.7	12.6	54.4	24.3
7	106	8.5	13.2	51.9	26.4
8	107	8.4	13.1	52.8	25.2
9	108	9.3	12.0	51.4	24.5
10	108	8.3	12.0	52.8	25.9
11	110	8.6	12.7	52.7	25.0
12	116	8.6	12.5	52.0	25.0
13	117	9.0	12.8	51.3	25.6
14	127	7.9	12.2	52.4	26.0
15	130	8.5	13.8	53.1	23.5
16	130	7.7	12.3	51.5	23.5
17	136	8.1	12.5	52.2	25.7
18	139	7.9	12.2	52.5	24.5
19	141	7.8	12.1	53.2	23.8
20	144	7.6	11.8	52.1	27.1
21	150	8.7	13.0	54.0	23.3
22	150	8.0	12.0	52.7	27.0
23	154	7.8	12.3	50.6	26.9
24	158	7.9	12.0	50.6	28.5
Ave.	122	8.4	12.6	52.1	25.3

LIFE HISTORY.—The small sucking-disc with blunt and feebly developed teeth, and the already degenerated digestive tract of newly transformed individuals, reveal that *zanandrei*, like *planeri*, is a nonparasitic species. No doubt the classical observations by Weissenberg (1925) and Keibel (1927) on the digestive tract and its glands in *L. fluviatilis* and *L. planeri* are applicable to the new species as well.

AMMOCOETES

It was shown in an earlier publication (Vladikov, 1950: 79–90) that the most important characters for identification of ammocoetes are the number of trunk myomeres and the pigmentation.

NUMBER OF TRUNK MYOMERES.—The low number of myomeres in 28 ammocoetes of *zanandrei*, the length of which varies from 91 to 158 mm. (ave. 121.6 mm.), contrasts greatly with the counts for ammocoetes of *planeri* from different European countries (Table VII). In 84 ammocoetes of *planeri* there are from 58 to 64 (ave. 60.7) myomeres, whereas *zanandrei* has only 52 to 56 (ave. 53.6). Thus there is an average difference of 7 myomeres between the two species and no overlap in their counts.

PIGMENTATION.—The pattern and extent of dark greyish pigmentation of the different sections of the head and body of the ammocoetes are very important taxonomic characters, as illustrated by Vladikov (1950: 83–90, figs. 4–8). They are particularly well shown in specimens which were placed alive in 4–5 percent formalin. It is preferable also, after initial fixing in formalin, to store ammocoetes in this preservative instead of in alcohol.

There are three pigmentation areas of particular importance on the head region: upper lip, prebranchial blotch, and branchial region. In Table X are summarized the peculiarities of pigmentation in ammocoetes of *zanandrei* and *planeri*. For classification, four degrees of pigmentation are used, ranging from an absence of pigment to its strong development.

Only 3 (10.7%) of the 28 ammocoetes of *zanandrei* lacked pigment on the lower edge of the upper lip, while all of the 64 ammocoetes of *planeri* have an unpigmented lip (Pl. II and Table X). The prebranchial blotch in 89 percent of *zanandrei* is either moderately or strongly developed, while in 72 percent of *planeri* it is absent.

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TABLE IX
COMPARISON BETWEEN BODY PROPORTIONS OF AMMOCOETES OF TWO SPECIES OF LAMPREYS
Minimum, maximum, and (in italics) average values are given

Species	Locality	TL (mm)	N	$\frac{d-B_1}{TL}$	$\frac{B_1-B_2}{TL}$	$\frac{B_2-a}{TL}$	$\frac{a-C}{TL}$
<i>L. planeri</i>	R. Morge, France	123-164 <i>145</i>	12	7.1-8.1 <i>7.5</i>	10.4-11.4 <i>11.1</i>	50.3-55.2 <i>52.7</i>	25.2-28.6 <i>26.6</i>
<i>L. planeri</i>	R. Auzon, France	132-177 <i>149</i>	11	7.0-8.2 <i>7.3</i>	9.0-11.6 <i>10.6</i>	51.3-54.8 <i>52.8</i>	25.0-28.1 <i>26.6</i>
<i>L. zanandrei</i>	Italy	91-158 <i>122</i>	24	7.6-9.3 <i>8.4</i>	11.8-13.4 <i>12.6</i>	50.5-54.4 <i>52.1</i>	23.3-28.5 <i>25.3</i>

There exists also a pronounced difference in pigmentation of the branchial region. In only one ammocoete (3.6%) of *zanandrei* was this region poorly pigmented, while in 57 percent it descended quite close to or touched the horizontal groove. In contrast, 95 percent of the specimens of *planeri* had a broad unpigmented band above the horizontal groove, and the remaining 5 percent had only weakly developed pigment (Table X and Pl. II).

In the tail region, the degree of pigmentation of the caudal fin is a very important character. In all ammocoetes of *zanandrei*, pigmentation is present around the notochord, varying from moderately to strongly developed in 64 percent (Table X). In contrast, this pigmentation was completely lacking in 98 percent of *planeri* (Pl. III).

In *zanandrei*, the pigmentation is well de-

veloped also along the lower edge of the caudal peduncle and the trunk as well as on the ventral surface (Pl. IV). In ammocoetes of *planeri*, this pigmentation is very weakly developed or lacking.

BODY PROPORTIONS.—The differences in body proportions observed in transformed individuals (Table V) are noticeable also in the ammocoetes (Table IX). On the average, the ammocoetes of *zanandrei* have shorter tails, the length of which is 25.3, while in *planeri*, from two different French rivers, this value is 26.6.

The most striking difference is found in the length of the branchial region, which is longer in every ammocoete of *zanandrei*. Its range is from 11.8 to 13.8, with an average of 12.6. In ammocoetes of *planeri* from two different rivers, this character varied from 9.0 to 11.6, with respective averages of 10.6 and 11.1.

TABLE X
VARIATION IN THE DEGREE OF PIGMENTATION ON THE TAIL AND DIFFERENT SECTIONS OF THE HEAD OF AMMOCOETES OF TWO SPECIES OF LAMPREYS

There are four degrees of pigmentation: — = absence of pigmentation; + = weak development; ++ = moderate development, and +++ = strong development.

Country	Specimens	Tail				Upper lip				Prebranchial blotch				Branchial region			
		—	+	++	+++	—	+	++	+++	—	+	++	+++	—	+	++	+++
<i>Lampetra zanandrei</i>																	
Italy	28	..	10	16	2	3	19	6	..	1	2	8	17	1	11	13	3
	%	..	35.7	57.1	7.2	10.7	67.9	21.4	..	3.6	7.1	28.6	60.7	3.6	39.3	46.4	10.7
<i>Lampetra planeri</i>																	
France	28	27	1	..	..	28	..	..	..	17	6	5	..	25	3	..	..
England	6	6	..	..	..	6	..	..	..	5	1	..	..	6	..	..	..
Czechoslovakia	11	11	..	..	..	11	..	..	..	9	1	1	..	11	..	..	..
Sweden	19	19	..	..	..	19	..	..	..	15	1	3	..	19	..	..	..
Total for Europe	64	63	1	..	..	64	..	..	..	46	9	9	..	61	3	..	..
	%	98.4	1.6	..	..	100.0	..	..	..	71.8	14.1	14.1	..	95.3	4.7	..	..

RELATIONSHIPS

Lampetra zanandreae is nearest to *L. planeri* (Bloch, 1784), a nonparasitic European species, and therefore it is necessary to compare the new species with *L. planeri*. However, the relationship between *L. planeri* and its nearest relative, *L. fluviatilis* (Linnaeus, 1758), a parasitic species, is rather a contradictory subject. While some authors (Regan, 1911; Léger, 1924; Weissenberg, 1927; D'Ancona, 1930; Berg, 1948; Oliva, 1953; etc.) considered them as two distinct species, there is another opinion, supported most recently by Enequist (1937), that they represent mere physiological forms of the same species. The present author is planning to publish in a separate paper his findings on morphological distinctions between these two species. Meanwhile, I consider *L. planeri* to be a distinct species from *L. fluviatilis*.

Among American species, *L. zanandreae* approaches *L. aepyptera* (Abbott) in the low number of its myomeres, but differs from the latter by better development of its teeth and by pronounced pigmentation of its ammocoetes. Further information on *L. aepyptera* is given by Vladyskov (1950) and Seversmith (1953). The relationship between *L. zanandreae* and *L. planeri* from western North America (Creaser and Hubbs, 1922; Schultz, 1930) will be discussed by the present author in a separate paper.

SUMMARY

In conclusion, the differences between *zanandreae* from northern Italy, and its nearest relative, *planeri*, from different European countries, could be summarized as follows:

TRANSFORMED SPECIMENS.—(1) Those of *zanandreae* could be distinguished from *planeri* by body proportions (Tables I-V), particularly by the length of the branchial region, which in average percentages of the total length is less than 9 in *planeri* and more than 10 in *zanandreae*. (2) There are fewer trunk myomeres in *zanandreae*, which vary from 54 to 60 (ave. 56.3), whereas in *planeri* they number from 60 to 65 (ave. 62.3). (3) There are the following differences in dentition of the disc: *zanandreae* has from 5 to 8 infraoral cusps, the average being 6.5, while *planeri* carries from 7 to 9 cusps, and the average is 7.1; *zanandreae* has from 5 to 7 denticles on the transversal lingual

lamina, and *planeri* shows from 9 to 13 denticles, the respective averages being 5.7 and 10.6.

AMMOCOETES.—(1) Those of *zanandreae* possess from 52 to 56 myomeres and average 53.6, whereas those of *planeri* have from 58 to 64 and average 60.7. (2) The body proportions, expressed in average percentages of the total length (Table IX), contrast as follows: the length of the tail in *zanandreae* is 25.3, while in *planeri* it is 26.6; the branchial region is longer in *zanandreae*, being 12.6, and only from 10.6 to 11.1 in *planeri* from two different French rivers. (3) The dark pigmentation is more strongly developed in *zanandreae* than in *planeri*: all specimens of *zanandreae* have such pigmentation on the caudal fin around the notochord, while this pigment is absent in all but 1.6 percent of *planeri*, where it shows only weakly; 89 percent of *zanandreae* have the lower edge of the upper lip pigmented and 96 percent have the prebranchial blotch, while all specimens of *planeri* lack pigment on the upper lip, and 72 percent are without the prebranchial blotch; the branchial region is pigmented in 96 percent of *zanandreae*, but only in 5 percent of *planeri*.

ACKNOWLEDGMENTS.—The present study was made possible through the cooperation of numerous persons from different countries, who kindly obtained the necessary material: from Czechoslovakia, Dr. Ota Oliva; from England, Mr. E. W. Baxter, and Drs. Winifred E. Frost and Ethelwynn Trewavas; from France, Dr. M. Fontaine and Messrs. J. Chaumont, J. B. Constant, M. Després, C. Ferdinand, R. Mangematin, A. Mazin, and H. Parrain; from Italy, Dr. Giuseppe Zanandrea; from Norway, Dr. C. Støp-Bowitz; and from Sweden, Drs. T. Lindström and S. Runnström. To all these persons the author wishes to express his most sincere thanks.

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Remarks on the Fish Genus *Mirolabrichthys*, with Description of a New Species

ALBERT W. C. T. HERRE

MANY years ago while inspecting a school of freshly caught juvenile *Caesio coeruleus* Lacépède, I noticed four small fishes which stood out from the rest. These were described as a new genus and species, *Mirolabrichthys tuka* Herre and Montalban. Now and then other specimens were observed in various localities in the Philippines, but never more than a few individuals were seen at one time. They were always mixed in schools of

small *Caesio coeruleus* Lac., *Caesio diagramma* Bleeker, *Caesio pisang* Bleeker, or *Caesio chrysazona* Cuv. and Val.

In the original description I made the erroneous remark that the genus was close to *Caesio*. In some ways there is an analogous resemblance, but it is a false analogy.

Fowler (1931) had more than 70 specimens and commented upon their systematic position. He retained them near *Caesio*, but remarked

that "they greatly suggest various aberrant members of the subfamily Anthiinae, in the Serranidae."

In working up Solomon Island fishes collected by Dr. W. M. Chapman, I found several small fishes which were set aside as evidently members of the Anthiinae. A year later, when these were studied, it was a surprise to find that two species of *Mirolabrichthys* were represented, together with *Luzonichthys waitei*. All the specimens were juvenile and were definitely anthiini fishes. I therefore have no hesitancy in stating that both *Mirolabrichthys* and *Luzonichthys* are aberrant Serranidae of the subfamily Anthiinae.

The extension of the range of these genera, previously known only from the central and southern Philippines and the waters about northern Celebes, is very interesting. These fish live on coral reefs where seines are useless, and well below the level reached by most fishing methods in such places. They were taken occasionally by the Muro (Caesio) ami (net) method, introduced into the Indonesian island world by Japanese fishermen. This method is a very successful way of taking schools of coral-reef-dwelling fish which will not take a hook. A full description of the process may be found in Montalban and Martin (1930). The method is no longer in use in the area, as the war eliminated all Japanese fishermen throughout the Philippines, East Indies, and Malaya. The Solomon Island specimens were taken by the use of dynamite.

The specimens mentioned in this paper are in the collection of the School of Fisheries of the University of Washington, Seattle. Lengths given are always the standard length.

Mirolabrichthys dispar, sp. nov.

Dorsal X-17; anal III-7; pectoral II-19; scales in the lateral line 58, plus 1 or 2 on the caudal base; 8 or 9 scales from the lateral line to the dorsal origin, 19 or 20 to the anal origin; about 30 predorsal scales; 8 or 9 transverse rows from the eye to the angle of the preopercle; 4 rows of scales on the maxillary expansion; gillrakers 7 plus 28.

The depth is nearly 3 times, the head 3.26, the deeply lobed caudal 2.58, the pointed pectoral 3.5 times in the length. The elongate ventral is 2.2 times in the length, its filiform

tip extending to the base of the sixth anal ray. The dorsal profile of the deep, somewhat ellipsoidal body is more strongly convex than the gently rounded ventral profile; an evident pointed conical papilla projects from the premaxillary, but is not as well developed as in specimens of *Mirolabrichthys tuka* of the same size. The circular eye is 3.75 times in the head and is approximately equal to the snout; no denticulations are visible on the posterior margin of the eye. The mouth is oblique; the maxillary extends beneath the middle of the eye, its length two and a seventh times in the eye, its greatest width 0.7 that of the eye.

The second and third dorsal spines are longest, about 2.5 times in the head; the remaining spines are a little shorter and subequal; the anterior dorsal rays are about as high as the posterior dorsal spines, gradually increasing in length posteriorly, the penultimate ray equal to the second spine. The anal spines are slender, the third one longest, 3.75 in the head; the third, fourth, and fifth anal rays longest, 2.5 times in the head.

The color in alcohol is uniform brown, with a reddish cast, and traces of a paler band (pinkish or reddish in life) from behind the eye to the middle of the caudal peduncle; above it a similar but narrow stripe extends from below the nape and in part along the lateral line to the upper part of the caudal base; a third parallel band runs from the pectoral axil to the lower part of the caudal peduncle; fins unmarked.

Here described from the holotype, No. 10628, 49 mm. long, from Gizo Island, Solomon Islands. Five paratypes, from 39 to 44 mm. in length, were collected at the same time and are listed under the same catalog number in the collection. The smaller specimens do not show the characteristic generic papilla on the premaxillary. Evidently it does not begin to develop until the fish has reached a length of 43 or 44 mm., or more.

This species differs from *Mirolabrichthys tuka* in its greater number of scales in the lateral line, its more numerous dorsal and pectoral rays, the much lower soft dorsal which does not exceed the spinous dorsal in height, and in the number of gillrakers. *Mirolabrichthys tuka* has 9 plus 22 gillrakers; as already stated *Mirolabrichthys dispar* has 7 plus 28. The

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poorer development of the rostral papilla is undoubtedly due to the specimens all being juvenile. I believe that *M. dispar* must reach a length of 100 mm. or more, and no doubt undergoes the same growth changes so notable in *M. tuka*, which reaches a length of 116 mm. or more.

Mirolabrichthys tuka Herre and Montalban

Three typical specimens, 34, 47, and 49 mm. in length, were taken from the outer reef on the north shore of Wana-Wana Island, Solomon Islands. Dorsal X-15 or X-16; anal III-7; scales in lateral line 48. The smallest specimen has no beak, but the other two have the typical flexible papilla on the tip of the snout.

Luzonichthys waitei (Fowler)

A single specimen, 36.5 mm. long, was collected on Wana-Wana reef, Blackett Straits, Solomon Islands. Hitherto this species has been known only from the central Philippines and off northern Celebes.

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The Grey Mullet of Kayamkulam Lake, India, and Their Fishery

C. MARY JOHN

INTRODUCTION

A FEW of the more common species of southern Indian mullets were recorded by Day (1865, 1878) and a more detailed report was made by Whitehouse (1922). Studies on the systematics and bionomics of mullets in Bombay, Calcutta, Baroda and Madras were reported by Fowler (1929), Pillay (1949), Chacko (1949) and Sarojini (1951). Except for the recording of a few species by Pillai (1929) and by the author John (1948), very little work has been done on these fishes in the Travancore-Cochin region. This area has extensive backwaters which provide ideal conditions for a large and varied mullet population.

Kayamkulam Lake is a narrow stretch of shallow backwater situated midway between Quilon and Alleppy, Travancore. It is about 10 miles long, $\frac{1}{2}$ to $1\frac{1}{2}$ miles wide, $2\frac{1}{2}$ to 3 feet deep at low tide, and roughly 10 square miles in area. It is separated from the sea by a narrow strip of coastal land which tapers to a bar near its southern end. The bar remains open for about nine months and is closed about the middle of May.

The bottom of the lake is largely sandy but

overlain by silt, and in the deeper parts there is soft dark clay with a little admixture of fine sand. In such regions the vegetation is poor, except for an encrustation of the blue-green alga *Oscillatoria*. The shallow sandy regions, however, have a luxuriant algal growth, especially during the hot months. The lake is highly saline for the greater part of the year. The shallow warm waters, with abundant vegetation and plankton, form an ideal feeding ground for both adult and fingerling mullets.

A study of the species is important for controlling, conserving and developing any fisheries. This work was therefore undertaken with a view to studying the systematics and general bionomics of the mullets in Kayamkulam Lake.

Of the 15 species of mullets identified, the majority are marine and migrate into the lake when the bar is open. During such periods, they constitute the most important fishery of the lake. Until 10 years ago, Kayamkulam Lake was famous for its mullets. Now, due to indiscriminate overfishing and the destruction of millions of fingerlings (locally called "Thuli"), the fishery has visibly declined and mullet

that once commonly attained a length of 2 feet are now a rarity.

The reader is referred to Weber and de Beaufort (1922) for the full synonymy of all the species up to 1922, except for *Liza macrolepis* and *Mugil poecilus*, which were not described by them.

SYSTEMATICS

The genera of mullets have been revised by Schultz (1946) and Smith (1947). I follow their classification in offering the following keys to the genera and species of Mugilidae in Kayamkulam Lake.

KEY TO THE GENERA OF MUGILIDAE

- A. Adipose eyelids covering more than $\frac{1}{2}$ of iris. *Mugil*
- B. Adipose eyelids feeble or absent. No papillae on upper lip. Pelvics always shorter than head without snout.
 - 1. Maxillae visible, caudal forked, scales normal, fins not black. *Liza*
 - 2. Maxillae hidden. Anal origin opposite second dorsal. *Valamugil*

KEY TO THE SPECIES OF *Mugil* LINNAEUS

- A. Anal with 8 soft rays; axillary scale present.
 - 1. Lateral scales 38-43; maxillae hidden. *M. cephalus*
 - 2. Lateral scales 30-35; maxillae visible. *M. subviridis*
- B. Anal with 9 soft rays.
 - 1. Maxillae hidden; lateral scales 33-35.
 - x. Pectorals shorter than head length; caudal peduncle two-thirds that length. *M. engeli*
 - y. Pectorals longer than head length; caudal peduncle twice that length. *M. longimanus*
 - 2. Maxillae visible.
 - a. Pectorals shorter than head length.
 - x. Lateral scales 28-31; $\frac{1}{2}$ of anal before origin of second dorsal. *M. dussumieri*
 - y. Lateral scales 33-35; $\frac{1}{2}$ of anal before origin of second dorsal.
 - 1. Scales without markings. *M. tade*
 - 2. Each scale with a black spot or band in the center. *M. poecilus*
 - b. Pectorals equal to or (in adult) somewhat longer than head length; lateral scales 36-38; body cylindrical and mandibular angle obtuse; fins not scaly. *M. ophuyseni*
 - c. Pectorals not much shorter than or nearly equal to head length; lateral scales 40-43; body compressed and mandibular angle acute; fins scaly; a small dark axillary spot present. *M. speigleri*

Mugil cephalus Linnaeus

Mugil cephalus.—Weber and de Beaufort, 1922: 253.

This is a species of great economic importance as it is caught in large numbers near the bar

mouth, from July to January. Its length varies from 9 inches to more than 2 feet. It is locally known as "Karinchi" or "Elameen," and is a great favorite for the table. This species has been found with roe from October to January; Breder (1940) has made similar observations on the Florida coast. This mullet migrates in shoals of 8 to 12 individuals and is said to be sportive, leaping into the air when disturbed.

M. cephalus is almost cosmopolitan in distribution. Its range in India includes Bengal, Kathiawar, Bombay, Madras, Tuticorin, Chilka Lake, Malabar and Travancore-Cochin State. It is known to occur in salt, brackish and fresh water.

Mugil subviridis Cuvier and Valenciennes

Mugil subviridis.—Weber and de Beaufort, 1922: 243.

This is a small species, ranging from 5 to 7 inches in length. It is locally called "Thottu Kanambu" (canal mullet) due to its habit of ascending rivers and canals. Although found throughout the year, it is rather rare. The breeding period is not known.

In India, it is known from the Ganges River, Chilka Lake, Malabar and Travancore-Cochin State. It also occurs in the Indo-Australian Archipelago, the Philippines and Cape York, Australia. A mullet of the sea, entering fresh water.

Mugil engeli Bleeker

Mugil engeli.—Weber and de Beaufort, 1922: 238.
Mugil keelarthi.—Sarojini, 1951: 163.

A rather rare mullet found only in the vicinity of the bar mouth from October to February, this species ranges from 4 to 7 inches long. It is locally called "Maala Kanambu," and contains roe from October to December.

It is found in the sea and brackish water in Tuticorin and Travancore-Cochin State, and in the Philippines.

Mugil longimanus Günther

Mugil longimanus.—Weber and de Beaufort, 1922: 239.
Mugil cunnesius.—Sarojini, 1951: 162.

A mullet abundant in the more saline regions of the lake from September to April and ranging in length from 5 to 9 inches. They are usually caught in large shoals and are well

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known for their ability to jump out of nets. This species is locally known as "Kadatha" and contains roe from September to December.

Indian records include Chilka Lake, Malabar and Travancore-Cochin State; elsewhere it is known from the Indian Ocean, Malayan Archipelago, Indo-Australian Archipelago and Abyssinia. It occurs in the sea and in brackish water.

Mugil dussumieri Cuvier and Valenciennes

Mugil dussumieri.—Weber and de Beaufort, 1922: 235.

This species is taken in all regions of the lake from July to February and varies from 5 to 9 inches in length. It is locally called "Varichi maala" which means "striped mullet," due to the conspicuous black longitudinal stripes. Roe is present from September to February.

It is known from Madras, Tuticorin, Malabar and Travancore-Cochin State, and from the Andamans, Thailand and the Indo-Australian Archipelago. It lives in the sea and in fresh water.

Mugil tade Forskål

Mugil tade.—Weber and de Beaufort, 1922: 136.

This mullet is common in the saline regions of the lake from July to February and forms an important fishery. It also is called "Varichi maala," but in this species the stripes are not distinct. The length ranges from 5 to 18 inches and roe is developed from September to March.

The Indian distribution includes River Hoogly, Madras, Tuticorin, Malabar and Travancore-Cochin State. It also occurs in the Andamans, Malay Archipelago, Indo-Australian Archipelago and China, inhabiting estuaries and tidal rivers.

Mugil poecilus Day

Mugil poecilus.—Day, 1878: 351.

Found frequenting the vegetation of the mangrove swamps, this mullet is locally called "Kaattu Maala" (swamp mullet) in reference to its preferred habitat. It grows to a length of from 5 to 9 inches. This species is usually not met with in open waters, and its breeding period is unknown.

It is known only from brackish waters of

India: Bombay, West Coast, Malabar and Travancore-Cochin State.

Mugil ophuyseni Bleeker

Mugil ophuyseni.—Weber and de Beaufort, 1922: 240.

A small mullet locally called "Kavalen," this species varies in length from 3 to 7 inches. It is found throughout the year and in all regions of the lake, and is believed to be a permanent denizen of the lake. Roe has been observed from November to February.

In India, it occurs in Bombay and Travancore-Cochin State; elsewhere it inhabits Java, Sumatra and Lirung. It lives in the sea and in brackish water.

Mugil speigleri Bleeker

Mugil speigleri.—Weber and de Beaufort, 1922: 241.

This species also goes by the same local name as *M. ophuyseni*, and has the same range of length and similar habits. It is common throughout the year, and contains roe from December to March.

It is recorded from Bengal, Orissa, Malabar and Travancore-Cochin State, and from the Malayan Archipelago, Indo-Australian Archipelago and South Africa.

KEY TO THE SPECIES OF *Liza* JORDAN AND SWAIN

- A. Anal entirely before second dorsal. Lateral scales 30-34.
 1. Lateral scales 30-31; mandibular angle acute; axillary scale present. *L. ceramensis*
 2. Lateral scales 32-34; mandibular angle obtuse; axillary scale absent. *L. borneensis*
- B. One-third of anal before second dorsal; mandibular angle obtuse; no axillary scale.
 1. First dorsal spine nearer base of caudal than end of snout; scales normal. *L. troscheli*
 2. First dorsal spine midway between base of caudal fin and end of snout. Scales thin and enlarged. *L. macrolepis*

Liza ceramensis Bleeker

Mugil ceramensis.—Weber and de Beaufort, 1922: 247.

This species is restricted to the regions of the lake adjoining the bar mouth, from July to November, and it varies from 3 to 6 inches long. A rare species, locally called by the common term "Kanambu," its breeding period is not known. This is the first record of the species from India.

Its extralimital range includes the Malayan

Archipelago, the Indo-Australian Archipelago, China and the Philippines, and it inhabits the sea and brackish water.

Liza borneensis Bleeker

Mugil borneensis.—Weber and de Beaufort, 1922: 249.

This mullet is only occasionally found in the regions of the lake that adjoin the bar mouth. Its length ranges from 7 to over 13 inches. The vernacular for it is the popular name "Veza-maala." The time of breeding is not known.

Its distribution in India includes only Travancore-Cochin State, but elsewhere it is known from the Malay Archipelago and the Indo-Australian Archipelago.

Liza troscheli Bleeker

Mugil troscheli.—Weber and de Beaufort, 1922: 248

One of the larger species also known locally as "Veza-maala," this mullet varies from 6 to 12 inches long. It is common throughout the lake from July to April, and roe has been found from September to December.

It occurs in Chilka Lake, Kathiawar, Madras, Tuticorin, Malabar and Travancore-Cochin State. Also, in the Indian Ocean, the Andamans and the Malayan Archipelago. It is found in the sea and in brackish water.

Liza macrolepis Smith

Mugil macrolepis.—Smith, 1846; Pl. 28, fig. 2.

Mugil smithii.—Günther, 1861: 447.

Mugil macrolepis.—Boulenger, 1916: 94.

Mugil macrolepis.—Smith, 1935: 628.

Liza macrolepis.—Smith, 1947: 840.

Mugil smithii.—John, 1948: 7.

Mugil smithii.—Sarojini, 1951: 162.

This species is second only to *Mugil cephalus* in economic importance. Known locally as "Kadal Maala" (sea mullet), it grows to over 2 feet in length. The characteristic nature of its scales, the width of the caudal peduncle, and the sturdy form of its body easily distinguish this mullet from the other species. It is of uniform silvery color, with a dark olive tinge on the dorsum. This species migrates in groups of 3 to 15 from November to April, and contains roe from November to January.

It is known in the sea, brackish water, and fresh water in Travancore-Cochin State, India, and in South Africa.

KEY TO THE SPECIES OF *Valamugil* SMITH

- A. Lateral scales 29–40; pectorals longer than head without snout. *V. coerulomaculatus*
B. Lateral scales 41–49; pectorals shorter than head without snout. *V. seheli*

Valamugil coerulomaculatus Lacépède

Mugil coerulomaculatus.—Weber and de Beaufort, 1922: 250.

This is one of the common species of mullets found in Kayamkulam Lake. It varies in length from 5 to 9 inches and is locally called by the general name of "Kanambu." The breeding period is not known.

Its Indian distribution includes Madras, Chilka Lake, Tuticorin and Bombay; elsewhere it is known from the Malayan Archipelago, Andamans, Mauritius and the East Indies. Its habitat is in the sea and brackish water.

Valamugil seheli Forskål

Mugil seheli.—Weber and de Beaufort, 1922: 252.

Valamugil seheli.—Smith, 1947: 842.

This mullet is uncommon, being found in the regions adjoining the bar mouth from October to January. It ranges in length from 7 to 12 inches and bears the same local name as the preceding species. Its breeding period is unknown.

In India, it occurs in Kathiawar, Madras and Travancore-Cochin State, and it is also known from the Gulf of Mannar and Andamans. It lives in the sea and brackish water.

DISCUSSION

Smith (1935) suggested that *Liza troscheli*, *L. borneensis* and *L. olivaceus* Day (1878) may be synonymous with *L. macrolepis*. Weber and de Beaufort (1922) differentiated between *L. troscheli* and *L. borneensis*, but did not mention either *L. olivaceus* or *L. macrolepis*. In Kayamkulam Lake, *L. troscheli*, *L. macrolepis* and *L. borneensis* are found together and in abundance. It is possible to identify the three species by external characters. *L. olivaceus* has been recorded from other parts of India. It is readily distinguished from *L. troscheli* and *L. macrolepis* by the presence of an axillary scale, and from *L. borneensis* in having the origin of the anal fin one-third before the origin of the second dorsal.

MULLET FISHERY

Mulletts enter backwater regions either for feeding or for breeding (Breder, 1940; Kes-taven, 1942; Jacob and Krishnamurthy, 1948; and Thomson, 1950). In Kayamkulam Lake they enter in large numbers from June to May when the bar is open. Usually they show a desire to swim against the current, feeding on the incoming plankton and organic debris, and ordinarily enter the lake at ebb tide and leave at high tide. Fishing is done on the basis of this knowledge either early in the morning from 3 AM to 12 noon, or from 4 PM to midnight.

From September to June the lake teems with millions of mullet fingerlings, locally called "Thuli," that range from 1 cm. to 7 cm. in length; in October and March there is a preponderance of the 3-cm. and 7-cm. groups, respectively. Chidambarum and Kurien (1953) have collected mullet fry almost throughout the year from the inshore areas of Krusadi Island. Fingerlings ranging from 1 cm. to 3 cm. are seen near the shore in shallow water where there is a good growth of algae, or in the mangrove swamps where the average depth is 1 to 1½ feet. Those mullets ranging from 4 cm. to 7 cm. long are seen in large surface shoals in the deeper waters, feeding on plankton and organic debris. Usually these individuals are observed to be shoaling by about 11 AM. Their presence is indicated by a peculiar shivering on the surface of water and a slight color difference, and fishermen are able to locate them easily from a distance. On the basis of the above knowledge, "Thuli" fishing is conducted from about 12 noon to 4 PM. A special type of drag net, called Nerya Vala, is used, and a single shoal sometimes yields as much as 100 to 150 pounds of mullet fingerlings.

Mulletts are noted for their swiftness and agility. They can easily jump over barriers and can see long distances. Hence much ingenuity has been shown by the local fishermen in combining various devices for catching them. The implements used for mullet fishing in Kayamkulam Lake are the following:

(1) CAST NETS: 2 to 3 cast nets, each with a length of 10½ to 13 feet, are used separately from boats in combination with a surface scare line 100 to 150 feet long. The scare line is made to skim over a large area of the water and drive

the mullets to the nets, which are cast simultaneously.

(2) DRAG NETS: These are of two kinds: "Nerya Vala," with a length of 210 feet, 18 feet deep, ¼-inch mesh made of 20s cotton yarn, and used mainly for catching mullet fingerlings or "Thuli"; and "Thelंगा Vala," a net 360 feet long, 24 feet deep, of ½-inch mesh, made of 20s cotton yarn, and used for catching large mullets. Generally 2 to 3 nets work together and surround a large area of the lake before separation and hauling up of the catch.

(3) DRIFT NETS: These are locally called "Noo Vala" and are 1000 to 1500 feet long, 9 feet deep, of 1-inch mesh, made of 20s cotton yarn, and provided with floats. The nets are set in a maze-like manner across the lake. Only mullets over 9 inches long are caught in this net.

(4) STAKE NETS: The length is 20 to 30 feet, the mesh ½ to ¾ inch. They are conical, sleeve-shaped nets tied to stakes at the bar mouth during ebb tide. The main catch consists of prawns, but a small quantity of mullets 3 to 4 inches long are also caught.

ACKNOWLEDGMENT

The author is indebted to the Travancore University for all facilities for conducting the above study and to Dr. Ross F. Nigrelli, of the New York Zoological Society, for his comments on this paper, and for helpful advice.

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A Review of the Black Sea Fish Fauna and General Marine Life Conditions

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THE latitude of the Black Sea extends from 46°30' to 40°56' N. and its longitude from 27°27'30" to 41°47'30" E. The northeastern part is connected with the Azov Sea by the Kerchenski Strait. In the south, the Bosphorus unites it with the Sea of Marmara and in turn the Sea of Marmara is connected with the Aegean Sea and the Mediterranean Sea by the Dardanelles.

The greatest length of the Black Sea reaches 982 km. from west to east and its greatest width equals 531 km. from north to south. Its narrowest portion lies south of Crimea towards the shores of Anatolia and equals 229 km. The surface area occupies 411,540 sq. km. and the volume of its waters is calculated to be 492,565 cubic km. The surface of the Azov Sea (without Sivash) equals 37,604 sq. km.

The Black Sea and the Azov Sea are bodies of brackish water with a low saline content. The temperature of sea water at maximum density in these seas is higher than the freezing

point; the salinity of the water, however, is higher than in the freshwater basins. The upper limit of salinity is equal to 24.695 0/00. At that degree of salinity, the temperature of highest density and freezing coincides and is equal to -1.333° C. When there is a higher degree of salinity the temperature of highest density is lower than the freezing point. These limits determine the conditions of vertical circulation. The approximate lower limit of salinity is 3 parts per thousand.

A distinctive feature of these seas is the discharge into them of great volumes of fresh water by the rivers and the inflow of waters with a relatively high salt content, from the Sea of Marmara into the Black Sea and from the Black Sea into the Azov Sea. A common feature of the two seas is the similarity of marine life. Their flora and fauna are of poor quality, but on occasions are rich in quantity. The Black Sea is deeper over more of its basin, attaining a maximum depth of 2243 meters and an average depth of 1200 meters.

Marine life in the Black Sea is limited to a thin layer 225 m. thick, which decreases to 170 m. near the shore. Under this layer is the

¹This paper is a condensation of my monograph "The Fishes of the Black Sea Basin" which consists of special and general (hydrology, hydrobiology, zoogeography, faunal origin, geological history, etc.) parts and which was sent to Prof. C. Kosswig, University of Istanbul, in March 1950, for publication in Turkish and in English according to an agreement with the Turkish Government.

hydrogen sulphide zone, which occupies 85 to 90 percent of all the water. The upper layer of water is known for its hydrological changes, while the lower is remarkable for its stability of hydrological phenomena. In contradistinction to the Black Sea, the Azov Sea is comparatively shallow, with a maximum depth of 13¼ m. and an average depth of 6.8 meters. Due to the shallowness of the waters, strong winds easily stir it up and mix all layers of water from the surface to the bottom. In consequence, the whole depth of water is teaming with life.

The salt content in the water of the Black Sea is 17.18 to 18.08 ppt.; the salinity increasing with the depth so that at 1500–2000 m. it equals 22.59 ppt. The waters of the Bosphorus attain a salinity of 36.49 ppt. Because of a high salt content, the waters of the Sea of Marmara descend as a lower current of the Bosphorus and mix with the Black Sea waters. This creates a difference in saltiness between the different layers and hinders vertical circulation, which is of utmost importance in the hydrology and biology of seas. The salinity of the Azov Sea is found to average about 10.0 ppt.

The average temperature of the Black Sea at a depth of 2000 m. is 9.0° C., at 500 m. it is 8.84° C., and at depths of more than 200 m. the temperature usually does not fall below 7.0° C. The freezing point in the upper layers is from -0.92° to -0.97° C. The minimum temperature is found most often at a depth of 50–75 m., and the maximum at the surface. Large quantities of oxygen reach to 100 m. or as far as the vertical circulation extends. (The extreme lower limit is 225 m.) Beyond 100 m., the oxygen penetrates by diffusion where, alongside oxidized organic matter, hydrogen sulphide is also found. Hydrogen sulphide accumulates at that depth by restoration of sulphate as a result of the activities of bacteria, mainly of the genus *Microspira*, which inhabit the bottom sea-ooze of the Black Sea and the Azov Sea. Additional formation of H₂S as a result of decomposition of organic matter is very insignificant. The average content of H₂S from 150 to 2000 meters is 0.08 to 5.7 cm³ (c.c. per liter). Between the upper O₂ layer and lower H₂S layer an intermediate layer, containing very little oxygen, is found at depths of 100 to 200 meters. The existence of these layers produces two opposite zones. All plant and animal life is concentrated in the upper layer,

the lower boundary of animal life reaching from 87 to 225 meters. The average content of oxygen at the lower limits of animal life is lower than 0.5 cm³ and, more often, 0.3 cm³. Content of oxygen at different depths in the Black Sea fluctuates from 0 to 8.64 cm³, and in the Azov Sea from 0.83 to 10.0 cm³.

Hydrogen sulphide has a negative influence on the biology and on the fish productivity of the sea. It leaves unused the dead bodies of plants and animals falling to the sea bottom, as well as all kinds of organic matter. In the lower layers it reduces the surface of the bottom and therefore also the volume of water available for useful organic life. Due to this fact, the Black Sea has a low general biological and fish productivity. At the same time three-fifths of the surface of the bottom in the Azov Sea has a moderate or low general biological productivity, but it does have a high production of fish. This depends also on the shallowness, on the abundant supply of fresh water from the continent, and on the low salt content.

Alkalinity of the Black Sea is comparatively high, for it is 2½ to 3 times greater than the alkalinity that could be normally expected and actually exists in other seas with a similar content of salts. Thus in this case there is no connection between the alkalinity and the saltiness. Alkalinity in the Black Sea diminishes from the surface to depths of 150–200 m. and then increases again with the depth. The concentration of hydrogen ions in Black Sea waters varies from 7.54 to 8.43. As a rule it is highest at the surface, and in the spring it increases as a result of the development of phytoplankton.

A circular current runs counter-clockwise in the Black Sea in the deeper parts. Masses of Azov Sea water, well diluted by the fresh water, join this current after passing through the Kerchenski Strait. In the southwestern part of the Black Sea, waters of the sea flow out through the Bosphorus as surface currents which enter the Sea of Marmara. These currents are faster in June and July when their speed reaches 22.3 km. in 24 hours, and are slower in September and October when they may move at a speed of 16.7 km. in 24 hours. Under the influence of the wind, the speed of the currents may increase or decrease. The factors that influence the system of Black

Sea currents are the winds, the inflow of water from the Azov Sea, its outflow to the Sea of Marmara, the rotation of the earth, etc. The speed of the current in the Azov Sea is 0.3 to 0.6 mile an hour.

Only a small portion of sea bottom is lighted. The upper layers of Black Sea water are penetrated by light to a depth of 50 to 60 meters. The transparency of water is from 13 to 26 m., more often from 18 to 21 m., but in parts where the depth is less than 200 m., it varies from 1 to 30 meters. The waves raised by the wind stir up the waters to a depth of 30 to 35 meters. In the Azov Sea the whole depth of water is penetrated by light and all the layers of water are easily agitated by the winds. Marine life in the Azov Sea is subject to extreme changes of conditions.

The geological history of the Black Sea and conditions of its marine life are as follows. Before the Quaternary period, the so-called Pontic Basin occupied the location of the present-day Black Sea. It resembled the contemporaneous Caspian Sea. The Pontic Basin was connected with the Caspian Sea through the valley of the Manich River. (In our times, a canal was dug through the valley of this river to connect the Azov Sea and the Black Sea with the Caspian Sea). During the Quaternary period, the history of the Black Sea was marked by a repeated increase and decrease in the salinity of its waters. According to the most recent investigations, four such changes took place: the Old Euxine Sea, the Tyrrhenian Sea, the New Euxine Sea and the contemporary Black Sea. The Old Euxine Sea received great volumes of fresh water and had no connection with the Mediterranean Sea. Its fauna was made up of organisms habitually living in fresh or brackish waters. At a later period, when the Bosphorus-Dardanelles straits were formed, the Black Sea became connected with the Mediterranean, at which period in history the Black Sea was named the Tyrrhenian Sea. At that time the heavy salt waters of the Mediterranean rushed through the Bosphorus strait into the Black Sea, bringing with them the Mediterranean fauna which found better conditions for existence than in the present-day Black Sea. The freshwater fauna of the Tyrrhenian Sea was carried to the northern parts of the sea and into the rivers.

Part of this fauna died out, but leaving fossil proof of its existence, on the sea bottom.

In the next period the connection with the Mediterranean Sea was disrupted and there was formed the New Euxine Sea. The Black Sea now became for the second time a fresh water sea. The Mediterranean fauna of the Tyrrhenian Sea evidently disappeared, with the possible exception of the euryhaline forms. The brackish and freshwater fauna spread again from the northern parts of the sea and its rivers. Some investigators assign the appearance of H_2S in the Black Sea to this period. The contemporaneous Black Sea period began about five to six thousand years ago and the Black Sea again became connected with the Mediterranean. The increasing salinity of the Black Sea continues and at the same time its fauna is enriched by numerous new Mediterranean forms. In our time this process has not yet reached the degree of salinity which the Tyrrhenian Sea had at the time of the first invasion of Mediterranean waters. The Black Sea level was raised after the New Euxine period and the waters flooded rivers, creating brackish estuaries. Parallel with the encroachment of the Black Sea on the dry land, its depth in the central parts increased also as a result of the depressions of the sea bottom. As stated before, the Black Sea underwent a series of consecutive changes during the Quaternary period. Its waters repeatedly changed from brackish and fresh to a salinity equal to that of the south European seas. As a result of these changes of conditions the fauna repeatedly experienced unfavorable conditions. Part of the marine life was destroyed as a result of these changes and part adapted itself to the new conditions, or moved to more suitable portions of the Black Sea.

The fish fauna of the Black Sea basin is made up of 247 species and subspecies belonging to 123 genera and 57 families. It is significant that out of 57 families, 41 are represented by only one genus. Among the 247 species, 183 live in the brackish and less saline waters of the sea, or in the estuaries of rivers. The fauna of the basin of the Azov Sea consists of 125 species and subspecies which belong to 79 genera and 38 families. From among them, 82 species are found in the sea, and of this number, 60 species are permanent sea inhabitants. The

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composition and the character of the Black Sea fish fauna are determined by the summation of the hydrological and hydrobiological conditions. This is equally true for the present time as well as for the geological past.

Three different groups of fish are distinguished according to their origin in the fauna of the Black and Azov seas:

1. The relicts of the ancient Pontic brackish Tertiary fauna. They number about 34 species belonging to the Acipenseridae, Clupeidae, Salmonidae, Percidae, Gasterosteidae and Gobiidae.
2. The Mediterranean and Atlantic immigrants inhabiting the Black Sea from the time when the connection was established with the Black Sea. This group is represented by 115 species.
3. The freshwater species inhabiting fresh water and the brackish parts of the sea. There are about 40 species.

The following Pontic relicts were preserved in the well diluted freshwater parts of the Black Sea, especially in the estuaries of rivers and partially in the fresh waters of the lower parts of the rivers: *Percarina demidoffi* (Nordman), of the family Percidae, and *Caspiosoma caspium* (Kessler), *Benthophilus stellatus* (Sauvage), *Knipowitschia longicaudata* (Kessler), *Gobius kessleri* (Günther), and *Mesogobius gymnotrachelus* (Kessler) of the Gobiidae. Other species that form part of the marine life of the Black Sea with its rivers, but are not limited to the fresher parts and usually are not connected with the Azov Sea, are the following: *Caspialosa pontica* (Eichwald), *Caspialosa tanaica nordmanni* (Antipa) and, in part, *Huso huso* (L.), *Acipenser gildenstädti* (Brandt), *A. stellatus* (Pallas), and *A. nudi-ventris* (Lovetzky). There are also species which occur in both seas and combine life in the Black Sea with life in the Azov Sea. These species spend a portion of every year in the Black Sea and then enter the Azov Sea where they spawn and feed (in the sea or in the rivers). In the fall they return again. The following species lead this double life: *Caspialosa maeotica* (Grimm), *C. tanaica* (Grimm), and others.

Some Mediterranean species appear to be constant inhabitants of the Black Sea and its rivers, and have no biological connection with either the Mediterranean or the Azov seas. To

this group belong the majority of the animals inhabiting the Black Sea. Other species, such as *Engraulis encrasicolus maeoticus* (Pusanov) and *Mullus barbatus ponticus* (Essipov), are biologically connected with the Azov Sea.

And finally there are species such as the following which come to the Black Sea from the Mediterranean Sea but do not breed there: *Conger conger* (L.), *Zeus faber* (L.), *Naucrates ductor* (L.), *Boops boops* (L.), *Merluccius merluccius* (L.), *Lichia amia* (L.), *Xiphias gladius* (L.), *Dentex dentex* (L.), *Aurata aurata* (L.), and others. But some, for example, *Scomber scombrus* (L.), *Sarda sarda* (Bloch), and *Thunnus thynnus* (L.), appear in great numbers, and such fish as *Sarda sarda* and *Thunnus thynnus* are breeding in the Black Sea. Some from among the Mediterranean immigrants have developed into separate species or subspecies such as: *Engraulis encrasicolus ponticus* (Essipov), *E. encrasicolus maeoticus* (Pusanov), *Blennius ponticus* (Slastenenko), *B. knipowitschi* (Slastenenko), *Syngnathus nigrolineatus maeoticus* (Slastenenko), *Arnoglossus kessleri* Schmidt, and others.

In general the degree of adaptability differs greatly with the different species. Some remain in the open estuaries all year and from there swim up the rivers to spawn, but occasionally they were found in the open sea beyond the estuaries. Other species live in the more diluted freshwater parts of the estuaries, but some appear here only for a short time. Still others are found in the estuaries only exceptionally.

The migration of fish from the Mediterranean to the Black Sea has a very long history. One fifth of the Mediterranean fauna and about one third of the Aegean fauna penetrated the Black Sea. About one fourth of the species of the Aegean Sea (naturalized in the Black Sea) became permanent inhabitants of the Black Sea. There are about 200 species in the Sea of Marmara, of which 135 have entered the Black Sea.

The following factors are the principal ones that hinder the migration of fish into the Black Sea:

- (a) The presence of hydrogen sulphide in the lower layers of the Black Sea.
- (b) The shallowness of the Dardanelle and Bosphorus straits. (This interferes with the habits of some deepwater fish).

(c) The lower average yearly temperatures in the Black Sea in comparison with the Mediterranean Sea.

(d) The lower degree of salinity of the Black Sea.

Among the fish which could adapt themselves to the conditions of life in the Black Sea, not all became naturalized. Only those species which had the biological peculiarities suitable for life in the Black Sea, not only in the mature stages but also as eggs and larvae, became permanent inhabitants. We find among certain related species with similar environmental reactions that some of them naturalized in the Black Sea while others failed. For instance, *Serranus scriba* (L.) is widely known in the Black Sea but *S. cabrilla* (L.) is considered to be accidental; *Callionymus lyra* (L.) is absent in the Black Sea, while *Callionymus belenus* (Risso) and *C. festivus* (Pallas) are permanent inhabitants; *Trachinus draco* (L.) lives in the Black Sea whereas *T. vipera* is absent. There are species which are widespread in the Mediterranean and Aegean seas, the Sea of Marmara and in the Bosphorus, and which also inhabit the northern seas such as the Baltic, but they are absent in the Black Sea. This is of interest because the Black Sea is also suitable for their life requirements. To this group belong *Ammodytes tobianus*, *A. lanceolatus*, *Atherina presbyter*, *Blennius gattorugine*, *B. pholis*, *Rhombus maximus*, *Labrus bergylla*, *Crenilabrus melops*, and others.

Those Mediterranean species, which in all stages of their development lived in the upper layers of water or near the shore, became the permanent inhabitants of the Black Sea. The selection of species depended upon the ecology of their eggs and larvae. For instance, deep-sea species and those which descend to the depths to spawn are absent in the Black Sea, but species which migrate to the shores to spawn multiply freely.

Zoogeographically, the basin of the Black Sea is a part of the Black Sea district of the Ponto-Caspian-Aral Province. The Black Sea district includes the basins of the Black and Azov seas, the Sea of Marmara and part of the Aegean Sea. The endemic forms of this district are brackish-water fishes belonging to the genera *Percarina* and *Relictogobius*, and *Lampetra danfordi* (Regan), *L. mariae* (Berg), *Hucho*

hucho (L.), *Umbra cramerii* (Walbaum), *Asprozelus* (L.), *A. streber* (Siebold), *Acerina acerina* (Güldenstädt), and *Mesogobius gymnotrachelus* (Kessler). Species common to the Black and Caspian seas but absent elsewhere are *Acipenser güldenstädti* (Brandt), *A. stellatus* (Pallas), *Rutilus frisii* (Nordman), *Lucioperca volgensis* (Gmelin), *L. marina* (Cuvier), and also some species of the genera *Gobius*, *Bubyr*, *Caspisoma*, *Benthophiloides*, *Benthophilus* and *Caspialosa*, the latter genus represented by different subspecies in the Black and Caspian seas. The following species are common to the Ponto-Caspian-Aral province: *Acipenser nudiventris* (Lovetzky), *Chalcalburnus chalcoides* (Güldenstädt) and *Pungitius platygaster* (Kessler). Species which are widespread in the circumpolar province and which are also found in the Black Sea are: *Salmo trutta* (Pallas), *Thymallus thymallus* (L.), *Phoxinus phoxinus* (Pallas) and *Cottus poecilopus* (Heckel).

The relict character of the Ponto-Caspian-Aral province is explained by the fact that during the ice age the climate was somewhat milder than in northern lands and this enabled these species to survive the rigors of the ice age and later to spread more widely.

Two basins could be distinguished here in relation to fauna and hydrological conditions:

1. Euxine, including the Azov Sea and the northwestern part of the Black Sea.
2. The Black Sea, which includes the remaining deep portion of the Black Sea. This portion was limited in the past as it is now by the natural border of the hydrogen sulphide zone.

The origin of the Black Sea fish fauna is closely connected with the appearance of H_2S , as it limited life to the upper layer of water and near the shores. The formation of H_2S in the Black Sea is assigned by some authors to the time when the connection with the Mediterranean was formed. If so, then it is a recent phenomenon and in that case the conditions favorable for its formation, in deep layers of sea water, appeared only after such a connection was established. However, according to the opinions of other authors, at that time H_2S was present in some quantity in the deep layers of water in Pontic Sea. A similar condition is found today in the Caspian Sea. The inflow of Mediterranean waters only intensified the

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formation of H_2S . The relicts of the Pontic fauna now inhabiting certain parts of the Azov Sea and the estuaries of large rivers of the Black Sea (Acipenseridae, Clupeidae, Gobiidae, some mollusks and crustaceans) are identical with or closely related to the present fauna of the Caspian Sea. We may say that the fauna of the Pontic Sea greatly resembled in general features that of the Caspian Sea today. The similarity of the faunas leads to the conclusion that hydrological conditions of the Pontic Sea were also similar to those of the present Caspian Sea. In that case, the fauna of the Azov Sea, of the estuaries of the rivers, and of the north-western portions of the Black Sea adjoining the shores, could also be considered as representing the type of marine life characteristic of the Pontic basin.

The marine life of the Pontic basin, having preserved its character until the present time, became limited to certain positions of its former range due to the influence of the Mediterranean waters.

A supposition exists that the increase of salinity of the Black Sea caused the extinction of the larger part of the Pontic fauna. Only the anadromous species which moved to the Azov Sea, to the brackish parts of the Black Sea, and to the estuaries of rivers, or generally speaking to places where former conditions were preserved, escaped extinction. In my opinion the increase of salinity did not destroy the Pontic fauna, because portions of the Black Sea and the Azov Sea always have had conditions of life similar to that of the Pontic Sea. On the contrary, it seems that the increased salinity helped the development of the Pontic fauna after a depressing environment caused

by extreme freshwater conditions at the end of the ice age. It is also probable that, with the presence of H_2S in the Euxine basin, the conditions for its fauna did not differ much from that of the Black Sea.

The marine fauna of the contemporaneous Black Sea, in general, is young and a large part of it could not be much older than five or six thousand years, counting from the time of its last penetration. At the same time, some species have arrived only during the past few years.

In the future the changes of the hydrological conditions of the Black Sea, in regard to greater salinity and increase of temperature, etc., will be followed, no doubt, by an increase in Mediterranean and Atlantic species. At the same time, certain Pontic elements will extend their territory, reaching the limits of the Aegean Sea. Because of such an exchange of elements of the fauna, and of the waters, the differences in the fauna and the hydrological conditions of the Black Sea and the Aegean Sea will be less pronounced.

On the other hand, the dependence on fresh water of some freshwater or anadromous species will diminish, forming new Pontic forms. In this way, the future development of the fauna will express itself in the expansion in area for some, and the limiting in area for others, evolving distinct biological forms from the existing species. This does not imply the formation of new species, because such a process in nature is very limited and it is impossible to measure it by time or conditions.

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Ichthyological Notes

ARTIFICIAL PROPAGATION OF THE SEA LAMPREY, *PETROMYZON MARINUS*.—Observations on the gland products, gonads, and general characteristics of sexually mature sea lampreys, *Petromyzon marinus* (Linnaeus), from Lake Huron, and a need to obtain some information on very young larval lampreys, prompted an experiment on the stripping and hatching of eggs. Seventeen specimens were selected from a group of spawning mi-

grants which had been trapped in the Ocqueoc River, Michigan, during June and held in live-cars in the lake until early August. The 12 males ranged from 14.0 to 19.1 inches in length and 60 to 190 grams in weight; each had the prominent rope-like ridge on the mid-dorsal surface between the first dorsal fin and the branchial region. The 5 females ranged from 13.1 to 16.3 inches and 60 to 120 grams; they were swollen with eggs and each had

the fleshy keel between the anus and caudal fin. Both sexes exhibited deterioration of the eyes, dentition and epidermis.

Examination of a small amount of milt pressed from each of the males demonstrated that spermatozoons in each sample were motile, despite a lack of stimulation by female sex products. Thus, it was assumed that the 12 males were ripe.

The maturity of the 5 female lampreys was tested by gentle stripping. Two specimens from which eggs were readily voided were called ripe; eggs in the remaining females were still bound in ovarian tissue. An attempt was made immediately thereafter to fertilize eggs from the 5 females with milt obtained from the males.

Battery jars containing about $\frac{1}{8}$ " of water were used as receptacles for the eggs and milt. A lamprey was grasped about the head and the thumb was pressed firmly into the oral funnel; the animal was held partly within the container. Eggs or milt were forced from specimens by pressure exerted posteriorly from the branchial region. A male was the first to be stripped, followed quickly by a female. The contents of the jar were stirred thoroughly as the milt from a second male was added. After several minutes the battery jar was filled with fresh water and the mixture let stand.

A separate jar was used to hold the eggs collected from each of the 5 females. Within 1 hour, the eggs were washed and each container was refilled with fresh water. All water used during the experiment came from Lake Huron; its temperature during the incubation period averaged 70° F. (range: 67° to 72° F.).

Evidence of successful fertilization in eggs from the 2 ripe females was first noted in about 4 hours, when initial stages of cell division were observed. In 16 hours, most of the eggs from these two specimens showed multiple cleavage. No sign of cell division could be found in eggs forcibly stripped from unripe females, and after several days they were discarded.

The first ammocoetes hatched 10 days after the eggs were fertilized; most had appeared by 12 days, and the hatching was completed in 16 days. Although no counts were made, a large percentage of the eggs hatched but a great many ammocoetes died soon after. The highly active prolarvae were opaque due to yolk remaining within the body, and growth was rapid. The notochords were prominent and body segments were numerous and well defined.

Thirty of the newly hatched prolarvae were placed in a battery jar which contained about 2 inches of bottom material (sand and mud) taken from a typical larval bed in a nearby stream. Wild, young-of-year ammocoetes were screened from the bottom sediment before it was placed in the jar. The prolarvae squirmed constantly but seemed

unable to burrow into the mud. The water was agitated until a covering of sediment settled over them. When the mud was screened 6 days later, only 12 of the 30 specimens were found alive.

Another lot of 92, week-old prolarvae was placed in a large aquarium with a mixture of mud and sand on the bottom. Again the ammocoetes wriggled about on the surface but did not penetrate into the mud. At 2 weeks of age, the yolk inclusions disappeared from their bodies and the specimens became so translucent that they were very difficult to see. Whenever disturbed, they attempted to burrow into the mud but were largely unsuccessful until they were 3 weeks old.

It was impossible to furnish running water to the aquarium, but the standing water was often partially changed and the level was maintained at capacity. After the larvae had been in this tank for 1 month, they were checked for survival; only 9 individuals were found. They had a mean length of 9.9 mm., with a range of 9 to 11 mm. When these survivors were replaced in the aquarium, they promptly burrowed into the mud. The 2 that were still alive 2 months later measured 10 and 11 mm. No further growth was noted when the same pair was measured 3 weeks later at the age of 21 weeks. Observations were concluded at this point because of the small number of specimens and the difficulty of maintaining good water conditions.

The experiment proved that fertile eggs and milt can be stripped from ripe sea lampreys to produce larvae under laboratory conditions. Insofar as I could determine, this was the first attempt made in the artificial propagation of this species.

The present study was conducted at the Fish and Wildlife Service Laboratory, Hammond Bay, Michigan, during 1950. Assistance in the study was contributed by Dr. W. James Leach, Ohio State University.—ROBERT E. LENNON, *U. S. Fish and Wildlife Service, Kearneysville, West Virginia.*

BRONSONIAN KNOT.—In Hawaii, as perhaps elsewhere, fishermen are harassed by unwanted moray eels (*Gymnothorax*) which manage to get themselves hooked and then proceed to tie themselves into one or more knots with the leader. Where wire leaders are used, very often the knottings are so thorough that the leader is useless thenceforth and the eel itself has to be cut into pieces to release the hook. In numerous instances an eel will tie itself into a veritable ball with the wire cutting into the flesh deeply.

This peculiar habit of the moray eel meant nothing to me until, in 1952, Mr. Albert B. Bronson, of Guam, related a curious incident which he observed on that island on one of his reefing expeditions. He had broken open a small *Tridacna* clam, when a juvenile moray was attracted to it. This eel took a

bite of the clam meat, but, being a small, narrow, elongate fish having no purchase, it was unable to tear off a mouthful. It then began a knot, from its tail. The knot traveled antieriad the length of its body and, on passing over its head, created sufficient purchase so that a mouthful of the meat was torn off by the fish. Mrs. Elizabeth Bronson was an eyewitness of the incident. Mr. Bronson remarked that the eel was using its head in more ways than one. I immediately labeled the knot as the "Bronsonian Knot," in a humorous vein, naturally. The editor and his readers are invited to add to this story and to make any kind of remarks, kind or unkind.

It seems to me there is a definite type of behavior illustrated by one eel tearing itself a spot of dinner and another trying to tear itself from an implacable object, namely a barbed hook.—YOSHIO KONDO, *Terrestrial Malacologist, Bernice P. Bishop Museum, Honolulu, T. H.*

STETHOJULIS RENARDI, THE ADULT MALE OF THE LABRID FISH STETHOJULIS STRIGIVENTER.—In a collection of fishes from the Gilbert Islands, Oceania, are five specimens which I identified in the field as *Stethojulis renardi* (Bleeker, 1851) and five of *Stethojulis strigiventer* (Bennett, 1832). The specimens of *renardi* range from 72 to 75 mm. in standard length and were more colorful than the smaller individuals of *strigiventer* (52 to 69 mm.). The former had four dark-edged red lines on the head and body as shown in Bleeker's Atlas Ichthyologique (1862, vol. 1, pl. 43, fig. 2). The area between the two lowermost red lines was blue posterior to the eye, and the lower half of the body was whitish with traces of lengthwise narrow white lines. In the brown *strigiventer* (Bleeker, *ibid*, fig. 1) there are five or six narrow lengthwise white lines on the ventral half of the body. In both species there is a tiny black spot or pair of spots at the base of the caudal fin just above the last lateral-line scale. Specimens of *strigiventer* less than 64 mm. have a small black spot on the next to last dorsal ray near its base, and those smaller than 50 mm. display a similar spot on the next to last anal ray.

I was unable to distinguish the two species on any other basis than color. All of the meristic data (D IX, 11; A III, 11; P 14 or 15; lateral-line scales 27; gillrakers 24 to 26) are the same in both. In preservative, with the bright hues of *renardi* faded, several specimens were sorted with difficulty.

Sex determination revealed that all five specimens of *S. renardi* are males whereas the specimens of *strigiventer* represent both sexes. A series of the two species in the United States National Museum which were collected at Guam were examined. There were 18 specimens of *renardi* from 62 to 81 mm. in standard length, all of which were males. Forty-two specimens larger than 34 mm. (those less than 34

mm. could not be sexed with assurance) were labelled *strigiventer*; of these, 14 were females (63 to 68 mm. long) and the remainder consisted of 16 females and 12 males. No males with *strigiventer* coloration exceeded 62 mm. in standard length. Three male specimens, 61 to 62 mm. long, were intermediate in color pattern between typical *renardi* and *strigiventer*. I therefore conclude that *S. renardi* is the large adult male of *S. strigiventer*, and that the *renardi*-type color develops (at least at Guam) at a length of about 61 to 62 mm.

Maturity in the male seems to be reached before the *renardi* form is assumed, for specimens as small as 47 mm. have well-developed testes. The male apparently reaches a larger size than the female. The largest female specimen was 68 mm.; 10 males were longer than 70 mm.

Sexual dimorphism to the extent that the males and females bear different names is not unknown in the Labridae. Longley (in Longley and Hildebrand, 1941: 196) discussed a comparable situation in *Thalassoma bifasciatum* (Bloch), in which only the large male attains the "bifasciatum" color pattern. In another case, however, Günther (1909: 291, pl. 148) was in error in considering the form illustrated in figure C to be the female of *Thalassoma duperreyi* (Quoy and Gaimard) (fig. B). The former is another species, *T. ballienui* (Vallant and Sauvage), with the color inaccurately depicted.

Sexual dichromatism is far from being a widespread phenomenon in the wrasses; nevertheless more examples probably remain to be elucidated.

This paper is contribution No. 63, Hawaii Marine Laboratory in cooperation with the Department of Zoology and Entomology.—JOHN E. RANDALL, *Department of Zoology and Entomology, University of Hawaii, Honolulu, T. H.*

NOCTURNAL TERRESTRIAL HABITS OF THE TROPICAL GOBIOID FISH GOBIOMORUS DORMITOR, WITH REMARKS ON ITS ECOLOGY.—During the course of recent ecological work in México, the writer on several occasions encountered the metapil, *Gobiomorus dormitor* Lacépède, in a terrestrial situation. This phenomenon was observed only at night on the rock beaches or "playas" characteristic of headwater streams of the Rio Tamesí drainage in east-central México. These solitary fishes were never observed more than 4 or 5 feet from the water's edge and generally in the vicinity of one of the numerous columns of ants which foraged the playas after dark. Although it was suspected at the time that the fishes were feeding upon the ants, analyses of the contents of 7 stomachs failed to verify this idea. One specimen, however, did contain a large tarantula which was probably captured among the rocks of the playa. Local

natives appeared to be well aware of the nocturnal terrestrial forages of this species.

In shallow streams and arroyos the metapil was frequently observed resting on the bottom during the day and night or occasionally creeping slowly among rocks of the bottom. It was repeatedly seen to bury itself by fanning the bottom detritus with its fins and allowing such suspended material to fall upon it, thereby concealing all but the dorsally-placed eyes. This procedure commonly occurred if the fish was disturbed at night by a light or by gentle prodding with a stick. With stronger stimulation, it darted rapidly from its place of concealment, frequently leaping clear of the water, and the only specimen captured with a seine was taken in mid air as it attempted to leap over the raised cork line.

As noted above, the species is carnivorous, and analyses of 7 stomachs revealed 3 with no food, 2 with remains of (6+) fishes, 1 with (6+) aquatic insects, and 1 with a large tarantula and several unidentified arthropods. Meek and Hildebrand (1916, Field Mus. Nat. Hist. Zool. Ser., 10: 351) reported that this species "feeds on crustaceans, fishes, water beetles and apparently any other aquatic animal life of suitable size." Hildebrand (1938, *Ibid.*, 22: 339) further stated that "they are rather sluggish carnivorous fishes, generally occupying shallow weedy areas where they lie quietly, hiding more or less among the plants, from which they make quick excursions, if hunger prompts them, to seize almost any animal of suitable size that comes near." This species took a hook readily, and the banded characin, *Astyanax fasciatus*, was successfully used for bait, although the most efficient method of capture was spearing in shallow water at night.

Individuals of this species are solitary, and on only one occasion was a pair observed swimming together. The estimated frequency of individuals in a small arroyo was 1 per 20-30 meters of stream bank with approximately even distribution, raising the possibility of territorial behavior.

Gobiomorus dormitor is a euryhaline species and has been recorded from brackish coastal lagoons and freshwater streams entering the Gulf of Mexico and Caribbean Sea from Texas southward to Brazil. Its widespread distribution throughout the West Indian Islands indicates that it may also be at home in waters of marine salinity. Of the North American euryhaline fishes listed by Gunter (1942, Amer. Midl. Nat., 28: 303-26), *Anguilla rostrata* is probably the only species for which the terrestrial habit has previously been noted, this being the first terrestrial record for *G. dormitor*. In view of its wide range of habitat tolerance, detailed studies of osmoregulation, respiration, and locomotion in this species would be of considerable interest in eluci-

dating the behavior of this unusual gobioid fish.—REZNEAT M. DARNELL, *Department of Zoology, Tulane University, New Orleans, Louisiana.*

A CASE OF FISH POISONING FROM *CARANX IGNOBILIS* FORSKÅL FROM PALMYRA ISLAND, WITH COMMENTS ON THE SENSITIVITY OF THE MOUSE-INJECTION TECHNIQUE FOR THE SCREENING OF TOXIC FISHES.—Techniques used in screening fish tissue extracts for ichthyosarcotoxins have been reviewed in a previous paper (Halstead and Bunker, 1954, *COPEIA* (1): 1-11). In a more recent report (*Ibid.*, 1954, *Zoologica*, 39 (2): 61-77), the authors stated that "There is some question in regard to the interpretation of 'weakly positive' extracts in terms of human symptomatology." The purpose of the present paper is to report a case of ichthyosarcotoxism resulting from the eating of the flesh of a specimen of *Caranx ignobilis* Forskål which was considered to be of questionable toxicity, and to discuss this case in the light of the screening techniques used in this laboratory.

The fish was taken by surface casting with a chrome spoon in the West Lagoon, Palmyra Island, Line Islands. The specimen was large, measuring 1040 mm. in standard length. The behavior and examination of the fish failed to reveal any evidence of disease. Immediately after capture the specimen was placed in the deep freezer. It remained frozen until thawed for testing purposes in the laboratory at the School of Tropical and Preventive Medicine. Tissue extracts were prepared from the musculature, liver, gonads, intestines and intestinal contents, in the manner described by Halstead and Bunker (1954, *Zoologica*, 39 (2): 61-77). Four white laboratory mice of the California Caviary Strain No. 1, weighing between 15 and 22 g. were used in testing each of the extracts. One ml. of extract was injected intraperitoneally into each of the mice. The mice were then observed for a period of 36 hours for the development of symptoms. The muscle extract was negative in three of the mice, but one of them developed a pronounced lacrimation resulting in closure of the eyelids. According to the methods used in our Department, extracts producing one or more symptoms such as ruffling of the hair, ataxia, lacrimation, respiratory distress, hypoactivity, etc., are considered to be weakly positive. However, in this instance because of the development of only a single symptom in one mouse, the results of the test were considered to be questionable. The liver, gonads, and washed intestinal tract were completely negative (Table I), but the intestinal contents were moderately positive, killing two of the mice in 24 hours 45 minutes, and a third in 43 hours 16 minutes; the fourth mouse lived. Because of the results obtained from the muscle extract, the flesh was

TABLE I
TOXICITY OF SEVERAL CENTRAL PACIFIC CARANGIDS

Location	Species	Part of fish ¹	Re- sults ²
Line Islands Palmyra	<i>Caranx ignobilis</i>	M,L,G,I;IC	W;M
	" "	M,I,IC;L	N;M
	" sp.	M,L	N
	" <i>ignobilis</i>	M;L	N;M
Fanning	<i>Caranx lugubris</i>	I;L	N;W
	" "	M	N
Malden	<i>Caranx melampygus</i>	M	N
Phoenix Islands Canton	<i>Caranx melampygus</i>	M	N
	" "	M,L,I	N
	" "	M	N
Enderbury	<i>Caranx lugubris</i>	M	N
	" "	M	N
	" "	M,L,I	N
	" "	M	N
	" "	M	N
	" "	M,L,I	N
	" "	M,I;L	N;M
	" <i>melampygus</i>	M,I;L	N;M
	" <i>sexfasciatus</i>	M,I,G;L	N;M
	" "	M	N
Sydney	<i>Caranx lugubris</i>	M,I,L	N
	" "	M,I,G;L	N;M
	<i>Caranx lugubris</i>	M	N
Johnston Islands	" <i>sexfasciatus</i>	M,V	N
	<i>Caranx lugubris</i>	M	N
	" <i>melampygus</i>	M	N
	" "	M,V	W
	" "	M,V	W
	" "	M	N

¹ M—muscle, I—intestine, G—gonad, L—liver, V—viscera, IC—intestinal contents.

² N—non-toxic, W—weakly toxic, M—moderately toxic.

considered to be safe to eat. The following case of ichthyosarcotoxism, resulting from the ingestion of a portion of the flesh of the fish described above, gives some indication of the sensitivity and the reliability of the method currently being used in screening fishes for poisons.

Cases of fish poisoning from this same general Central Pacific region have been previously reported by Lee and Pang (1945, Hawaii Med. Jour., 4 (3): 129-32) and Ross (1947, Med. Jour. of Australia, 2 (21): 617-21).

CASE REPORT

March 26, 1954—A 27-year-old white female, in good health, consumed 3-4 ounces of the boiled flesh of the *Caranx ignobilis* described above. The remaining portion of the boiled fish was refriger-

ated. On the evening of the 26th the woman noticed that drinking cold water caused a mild tingling sensation in her lips.

March 27—The paresthesia was more pronounced, for drinking non-carbonated cold drinks produced the sensation that they were highly carbonated.

March 28—The patient complained of being unusually tired and though aware of the nature of the symptoms of fish poisoning had no indication that she had been poisoned. The paresthesia produced by cold drinks persisted.

March 29—The remainder of the boiled fish (at least a pound) was eaten. By evening very definite symptoms in the form of moderate to pronounced muscular weakness, nausea, and an overall cold feeling had developed. Later that evening the patient experienced a mild diarrhea and complained of dizziness upon standing. She was unable to touch anything cold without receiving a painful sensation similar to that of a "dry ice burn," whereas, if her hands were placed in warm water, the sensation was pleasant and relieved the cold feeling. Gastrointestinal distress, including vomiting and flatulence became very severe. Muscular weakness was so pronounced the patient was barely able to walk.

April 1—The gastrointestinal symptoms had subsided but the neurological symptoms, especially the muscular weakness, reached a maximum and from this date gradually subsided. During the subsequent three or four weeks, there persisted a moderate to mild muscular weakness, the unpleasant reaction received from touching cold objects and the tingling sensation of the mouth and lips on drinking anything cold. Complete recovery was not attained until two months after onset.

The patient failed to seek the advice of a physician; thus there are no data regarding any physical or laboratory findings. Treatment was symptomatic and consisted largely of bed rest.

DISCUSSION

Portions of the same fish were consumed over a period of several weeks by various individuals other than the one mentioned in the case reported above, and with no ill effects. However, in all cases except the one resulting in poisoning, the flesh was fried rather than boiled. The onset of the symptoms of poisoning suggests an accumulative effect. Whereas there was insufficient poison in the small amount of extracted muscle to produce toxic reactions in test mice, when a large amount of flesh was eaten sufficient poison was present to produce the symptoms observed. It will be remembered, also, that the effects were augmented by ingestion of flesh on sub-

Slippery Rock Creek and its tributaries. These herons were also observed to feed in the other streams sampled. Since these birds are the final hosts of *P. minimum*, it would be expected that this parasite would occur in the fish populations of the entire area. However, out of 5,000 rosyface shiners sampled, only the 1,000 specimens obtained from Slippery Rock Creek and its tributaries were infested with the metacercariae of *P. minimum*.—ROGER J. REED, *Pymatuning Laboratory of Field Biology, University of Pittsburgh, Pittsburgh 13, Pennsylvania*.

THE EFFECT OF SALINITY AND TEMPERATURE ON THE PRE-ADULT GROWTH OF GUPPIES.—This paper gives an account of a brief study of the guppy, *Lebistes reticulatus* (Peters), to compare rates of pre-adult growth at various temperatures over their range of thermal tolerance in both fresh water and dilute sea water.

The fish were taken from laboratory stock which had originally been obtained from various sources in Toronto. Gravid females were placed in gallon jars, one to a jar, and these jars were then suspended in various aquaria held at temperatures of 20°, 23°, 25°, 30° and 32° C. After young were born, the mothers were removed. Families were raised in this series of temperatures in fresh water and $\frac{1}{4}$ sea water except in 32° C, at which temperature one family was raised in fresh water only. In addition, two families in each of 20° and 25° C were raised in $\frac{1}{2}$ sea water. The method of suspending the jars was not a good one because of the hazard of tipping. For this reason records were obtained on only one family in $\frac{1}{4}$ sea water for both 20° and 23° C, although several were raised in fresh water at both temperatures.

The fish were anaesthetized in a 1 percent solution of ethyl carbamate (urethane), and the length of each from the tip of the snout to the end of the vertebral column was measured in millimeters with vernier calipers, under a binocular microscope. Afterwards they were placed in a beaker until they revived and were then replaced in their jar. The water used during these various steps was taken from the same jar as the fish, and temperatures were kept fairly constant during measuring.

The time of birth of the families to be measured was established to within 24 hours. At first the young fish were measured soon after birth, but it was found that they were too delicate to handle at this stage. After the first few attempts the fish were measured for the first time when approximately 2 days old. Further measurements were made at intervals of one or two weeks until the males in each family were mature.

The lengths of the various fish in each family were averaged each time measurements were taken

TEMPERATURES °C.					NO. OF FISH
20	23	25	30	32	IN SYMBOL
○	△	□	◇	▽	4 - 6
◐	▲	▢	◊	▼	7 - 10
◑	▴	▣	◈	⬇	11 - 15
●	▴	■	◆	⬇	OVER 16

Fig. 1. Symbols used in the graphs to designate temperatures and numbers of fish. In Fig. 4 the symbols indicating the results in fresh water are enclosed with a circle.

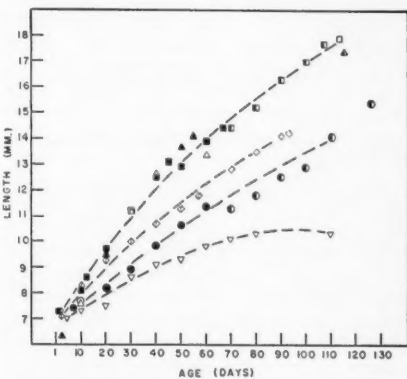


Fig. 2. Growth curves of guppies raised in fresh water at 20°, 23°, 25°, 30° and 32° C.

and these averages were plotted, using age in days by length in millimeters (Figs. 2, 3 and 5). Average lengths of each family at regular 10-day intervals were listed from the graphs. Where more than one family had been raised in any particular temperature and medium, the results were combined to form an over-all mean for that group. The system of symbols used throughout to designate the rearing temperatures and numbers of fish are shown in Fig. 1.

DIFFERENCES IN GROWTH RATE

The growth curves of guppies born and-raised in fresh water at temperatures of 20°, 23°, 25°, 30° and 32° C are illustrated in Fig. 2. When the results of each family were being plotted, it was observed that there was variation in rate of growth among families of similar environment. This variation is discernible in the figures. For instance, breaks in the curves are seen at 70, 60 and 50 days for the fish reared at 20°, 23° and 25° C, respectively. Since the points represent the over-all means of more than one family of fish, these breaks occur when measurements on one family (the fastest growing one) were discontinued

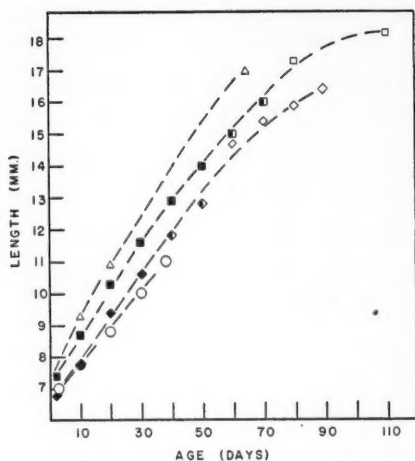


Fig. 3. Growth curves of guppies raised in $\frac{1}{4}$ sea water at 20°, 23°, 25° and 30°C.

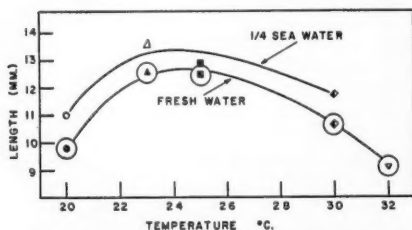


Fig. 4. Average lengths of guppies 40 days old in $\frac{1}{4}$ sea water and in fresh water at various temperatures.

and the remaining points are from families carried on for a longer time. However, the relative differences in growth rate among the various temperatures remain approximately the same after these breaks as before.

The fastest growth occurred at 23° and 25° C. In spite of a smaller average size at birth, fish reared at 23° C had reached approximately the same size as those from 25° C in 20 days time, and between 40 and 55 days had equalled and then surpassed them. Between 55 and 60 days, measurements of the faster-growing family at 23° C were discontinued (being mature), and from then on the fish reared at 25° C grew slightly faster than the remaining family from 23° C.

Up to 60 days the fish reared at 30° C were next in order of growth rate, with the 20° C group approaching them closely. It was at this time that the faster-growing family in 30° C was discontinued, and in another 10 days time the faster one in 20° C was also discontinued. However, there were very few fish included in the measurements of the 30° C fish

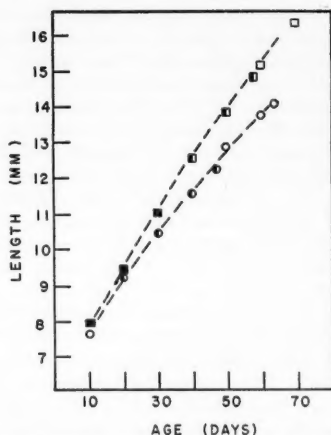


Fig. 5. Growth curves of guppies raised in $\frac{1}{2}$ sea water at 20° and 25°C.

as compared to the number of 20° C fish. It is unfortunate that the measurements of the 30° C fish were not continued longer than 93 days. At that time their rate of growth appeared to be decreasing whereas the 20° C fish were still growing at their accustomed rate at 126 days.

The family reared in fresh water at 32° C grew very slowly, and all had developed crooked spines when 22 days old; these malformities were retained even by those which were later transferred to 25° C.

From these tests it appears that the optimum temperature for rate of growth of the guppy in fresh water lies in the neighborhood of 23° to 25° C.

The results of measurements of fish reared in $\frac{1}{4}$ sea water are shown in Fig. 3. The same relative differences in rate of growth displayed among fish reared in fresh water were also maintained in $\frac{1}{4}$ sea water. The addition of sea water to about the equivalent of physiological saline was advantageous to the growth of the guppy at all temperatures for which there were comparable records. This is shown in Fig. 4, where a comparison is made of the mean lengths of fish 40 days old raised in fresh and in $\frac{1}{4}$ sea water at the various temperatures. This advantage was established in the majority of cases by 10 days of age and continued at least up to 60 days. One relatively fast-growing family in 30° C $\frac{1}{4}$ sea water even surpassed the growth rate of freshwater fish at 25° C during the period of 60 to 80 days of age. The fastest growth in any group occurred at 23° C in $\frac{1}{4}$ sea water.

Fig. 5 illustrates the lengths attained by fish reared at 20° and 25° C in $\frac{1}{2}$ sea water. The fish flourished in this medium also. The fish reared in $\frac{1}{2}$ sea water at 20° C have a slightly steeper growth curve than those reared in $\frac{1}{4}$ sea water at the same

TABLE I

NUMBER OF DAYS TO RECOGNITION OF FIRST MALE IN CERTAIN FAMILIES OF GUPIES IN VARIOUS MEDIA AND TEMPERATURES

Arranged in order of rate of growth

Medium	Temperature, °C				
	20°	23°	25°	30°	32°
Fresh water	86	38	26, 26, 49, 57	79	No males recorded up to 110
¼ sea water	41	..	35, 38, 51	70	..
½ sea water	..	..	28	..	..

temperature, but this may be only a familial difference.

Since the measurements were discontinued when the males became mature, there is no experimental evidence that the addition of sea water enhances the size of adult fish, and observation of fish in the laboratory at 25° C has not revealed any outstanding differences in size. Among the groups in various temperatures in fresh water however, it has been observed that much larger females develop at 20°, 23° and 25° C than so far have been found in 30° C.

Our samples of guppies did not show the same rates of growth as other workers have found. In contrast to the mean length of 12.5 mm. in 25° C at 40 days reported here, Svardson (1943, Kungl. Lantbruksstyrelsen, No. 21: 1-48) reported guppies at 25° C in fresh water which were over 16 mm. at that age, and Bertalanffy's (1938, Human Biol., 10: 181-213) guppies averaged about 22 mm. at 42 days in 24° C. Even among the few families reported here the variation in growth, probably of genetic origin, was substantial. However, the results show consistent differences in rate of growth over the thermal range of the guppy, with the optimum in both fresh and in ¼ sea water in the neighborhood of 23° to 25° C.

DIFFERENCES IN TIME TO MATURITY

While measurements were being taken, the development of the gonopodium of the males was observed and noted in certain series (Table I). In general, males were recognizable earlier in the faster-growing families at a given temperature. There was considerable variation among families but the rate of development was most rapid at 25° C. It was definitely slower at 20° and 30° C, and no male was apparent at 32° C at the end of 110 days when the test was discontinued, although males did subsequently develop after this group was transferred to 25° C.

ACKNOWLEDGEMENT.—This work was carried out at the Laboratory for Experimental Limnology,

Maple, Ontario, Canada, which is supported jointly by the University of Toronto and the Ontario Department of Lands and Forests. The authors wish to express their grateful thanks to the director of the laboratory, Dr. F. E. J. Fry, who supervised the project and edited the manuscript.—M. B. GIBSON and B. HIRST, *Southern Research Station, Maple, Ontario, and Ontario Fisheries Research Laboratory, University of Toronto, Toronto, Ontario, Canada.*

ILLUSTRATED WORKS ON FISHES.—It was gratifying to see published, a short time ago, a new bibliographic work on fishes, a little volume by Claus Nissen entitled *Shöne Fischbücher* (reviewed briefly in COPEIA, 1952 (3): 212). There has been developing for some time an increasing need for studies of fish literature to be conducted along both general and specialized lines. In this respect it is most unfortunate that Bashford Dean's monumental work was not continued by the ichthyologists at the American Museum. However, Nissen's book does fill part of the gap and it has additional interest because it presents a short history of ichthyological illustration. Its primary purpose is to present a list of the outstanding illustrated works on fishes, something which is of undoubted usefulness to professional and amateur alike.

Relatively few illustrated works on fishes can be termed "outstanding" and these are avidly sought by ichthyologists, librarians, and art collectors. A large percentage of the really fine old works have ceased to exist in a complete state. Their remnants can be seen only as scattered, individual plates which have been separated from the text by some ambitious art dealer. From a professional standpoint, the figures which adorn these older works are indispensable because it is often impossible to make a positive species identification through reference to the written description alone.

In recent years, there has been a tendency to forego illustrations of taxonomic work because of the publication expense, especially where colored plates are concerned. This is most regrettable since good illustrations, especially colored figures of fishes, can still add immeasurably to the practical and esthetic value of modern works. Unfortunately, the days of the lithographed, hand-colored plate have long since passed but this does not mean that contemporary artists and methods of printing cannot produce a first rate illustration. For example, the amazing diversity of a tropical marine fauna becomes beautifully apparent through the fine illustrations of Margaret M. Smith and her assistants in J. L. B. Smith's (1949) *The sea fishes of Southern Africa*. The plates executed by Maynard L. Reece for Harlan and Speaker's (1951) *Iowa fish and fishing* must surely rank with some of the best of all time. An outstanding example of the use of direct color

photography is given by Ralph Emerson in Walford's (1937) *Marine game fishes of the Pacific Coast*.

In attempting to use Mr. Nissen's work, some rather serious deficiencies have become apparent which should be remedied if this book is to adequately fulfill its purpose. Of the total list of 135 items, some (at least 14) are of quite minor importance and many of the major works have been omitted. The six non-European items are all American publications but these selections, unfortunately, do not represent the best efforts of American illustrators.

The finest American illustrated work on fishes is almost certainly that written by Samuel Garman (1899) on the fishes of the "Albatross" expedition. The lithographed plates, many of them colored, were executed by A. M. Westergren and J. Henry Blake. Another one of Garman's (1913) works, *The Plagiostomia* (plates by E. N. Fischer), also ranks very high as does Jordan and Evermann's (1905) beautiful book on the shore fishes of Hawaii (illustrations mostly by A. H. Baldwin). Forbes and Richardson's (1920) *The Fishes of Illinois* will always be a classic work. Chloe Leslie Starks has been, without doubt, the outstanding ichthyological illustrator in the pen and ink medium. Her work can be seen in Gilbert and Starks' (1904) *The Fishes of Panama Bay* and in Jordan and Evermann's (1896-1900) monumental contribution *The Fishes of North and Middle America*. None of these appears in Nissen's bibliography.

The fine Japanese iconographies were completely ignored. This is most regrettable since the work of many of the Japanese artists is comparable with the best. The colored fish plates by Toshio Kumada (1949) in his *Illustrations of edible aquatic fauna of the South Seas* can serve as a good example of artistic excellence combined with scientific accuracy. Direct color photography has also been used effectively by the Japanese as in the *Iconography of Japanese fishes* (in Japanese) by Y. Okada, K. Uchida, and K. Matsubara (1935).

In order to bring the bibliographic list in *Shône Fischbucher* to a reasonably satisfactory state of completion, it is proposed that the following 46 items be added:

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- JOHN C. BRIGGS, *Department of Biology, University of Florida, Gainesville, Florida*.

Herpetological Notes

OBSERVATIONS ON SOME AMPHIBIANS FROM GEORGIA.—In the last few years several amphibians of interest particularly to the taxonomist and to the zoogeographer have been collected in Georgia. Also, observations adding to our knowledge of the life histories and ecology of these forms have been made. All specimens referred to in this article (unless otherwise indicated) are in the University of Georgia Collection (UG) or in the private collection of Robert L. Humphries (RLH).

Desmognathus aeneus Brown and Bishop.—There are no previous records of the pigmy salamander's

occurrence in Georgia. Recently we have taken it in Fannin, Union, Towns, Rabun, and Lumpkin counties. Undoubtedly this species occurs throughout the Blue Ridge Mountains in the northeastern part of the state. Specimens were found under leaves, moss and stones in places of high humidity, particularly near seepages. The two smallest specimens measured 6.8, 10.5 mm. and 7.0, 11.0 mm. (snout-vent and total length). These were taken August 10, 1953, in the western part of Rabun County along a small tributary of the South Fork of Moccasin Creek. Presumably late July and early August is the

season during which transformation occurs in that locality. The largest specimen (UG 626) measured 27.5, 63.5 mm. (snout-vent and total length). This long-tailed specimen was taken 1.8 miles south-southeast of Brasstown Bald in Towns County. In general, adults were much smaller than the above mentioned specimen; ten large adults selected somewhat at random, averaged 44.5 mm. in total length. A study of the pigmy salamander in Georgia is in progress.

Leurognathus marmorata Moore.—Only a single specimen of this species, taken at Mountain City, Rabun County, is on record for Georgia (Pope and Hairston, 1947, Fieldiana, Zool., 31 (20): 155-62). Recently, however, two adults have been taken in the northern part of the state. One (UG 387) was collected in the western part of Rabun County in Wildcat Creek (Savannah River system) at an elevation of about 2,400 ft. It has no vomerine teeth, 14 costal grooves (2 in groin), $2\frac{1}{2}$ costal spaces between adpressed limbs, measures 109.5 mm. in total length and 60.5 mm. from snout to vent. The dorsal coloration is a medium brown with conspicuous olive-yellow or yellowish green blotches. These markings are arranged in alternate fashion; they are not opposite one another as in *L. intermedia*. The dorsal pattern is very similar to that shown by Bishop (1943, Handbook of Salamanders: 223) for *marmorata*. Pope and Hairston (*op. cit.*) indicated that the dorsal pattern of *intermedia* is "surprisingly diagnostic, 74 per cent showing the two rows of light spots. Those without spots are immaculate brown above. No indication of the zigzag design of *marmorata* is evident." The other specimen of *Leurognathus* (UG 402) was seined from the Soque River, a large tributary of the Chattahoochee, in the northwestern part of Habersham County at an elevation of about 1,600 ft. It, too, has no vomerine teeth, 14 costal grooves (2 in groin) and $2\frac{1}{2}$ costal spaces between the adpressed limbs. It is 110.5 mm. in total length and 62.0 mm. from snout to vent. Its dorsal coloration is dark brown with small yellowish brown blotches. These markings are intermediate in position between those of the specimen taken in Wildcat Creek and those described for *intermedia*.

We realize that from so few specimens no definite conclusions can be drawn; but on the other hand, *Leurognathus* is not an abundant animal, and only a relatively small number of specimens are available. Our material shows that the range of *Leurognathus* in Georgia conforms to the prediction of Pope and Hairston (*op. cit.*) and, further, that the taxonomy and distribution of our *intermedia* and *marmorata* are, as yet, not clear. Our specimens strongly suggest that the two forms are subspecies and that they intergrade in the Blue Ridge Mountains of north-eastern Georgia.

Plethodon jordani shermani Stejneger.—The red-

legged salamander has a very restricted distribution. Hairston and Pope (1948, Evolution, 2: 266-78) have indicated that it is confined to an area about 15 miles in diameter in the Nantahala Mountains of western North Carolina. On November 5, 1952, a juvenile was taken about one mile east of Patterson Gap, Rabun County; and on August 29, 1953, 13 specimens were taken along the Coleman River, one-half mile southeast of Chestnut Mountain, Rabun County, at an elevation of about 2,800 ft. Twelve of them have distinct red markings on their legs, but not so many as most specimens taken at Mooney Gap, North Carolina. The other lacks the red markings entirely; but even at Mooney Gap, Hairston and Pope (*op. cit.*) noted that one of 24 specimens lacked these markings. All Georgia individuals have white lateral, but no dorsal markings. Most are uniformly black on the ventral surface, but two have many large irregular-shaped white markings between the forelegs. All have 15 or 16 costal grooves; average, 15.2. The largest is 172 mm. in total length and 73 mm. from tip of snout to anterior part of vent. These Georgia records extend the known range about 5 miles southward.

Gyrinophilus danielsi dunni Mittleman and Jopson.—Even though Bishop (*op. cit.*) showed that the Carolina purple salamander ranges into the north-eastern part of Georgia, there are only a few specimens reported for this state. The three taken near Stone Mountain, DeKalb County, by John W. Crenshaw, Jr. (Neill, 1947, COPEIA (4): 271-2) and four taken at Athens, Clarke County, by Martof represent the only records we could find. Mittleman (1942, Proc. New England Zool. Club, 20: 25-42) stated that he examined specimens from Georgia but gave no specific locality data.

In our collections we have 24 specimens. These were taken in the following counties: Rabun, Habersham, White, Union, Fannin, and Lumpkin, all in the mountains of the northeastern part of the state at elevations between 2,000 and 4,000 ft. All but one of these specimens have 18 costal grooves on both sides, the exception has 17 grooves on one side. Nine adults average 76.2 mm. (range 63 to 86) in the snout-vent measurement and 129.4 mm. (range 105 to 152) in total length. These are smaller than the Clarke County specimens which average 84.8 mm. (range 80 to 88) in the snout-vent measurement and 151 mm. (range 140 to 159) in total length. Of the larvae, the two smallest were taken June 3, 1953; they measured 29, 56 and 32, 57 mm. (snout-vent and total length). Some of the larvae are larger than many of the transformed specimens. One larva measured 66, 121 mm., another 72, (tip of tail missing); and a very unusual specimen (RLH 739) was 83, 149 mm. This exceptional larva was taken in July, 1950, near Margret, Union County, at an elevation of 2,250 ft. It was reproductively

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functional, as shown by its testes which were proportionately larger than those of transformed specimens taken during the same month of the year. This is the first record of neoteny in this species.

Eurycea longicauda longicauda Green.—Intergrades between *E. l. longicauda* and *E. l. guttolineata* from Chatsworth, Murray County, have been described by Bailey (1937, Occ. Pap. Mus. Zool. Univ. Michigan, 643: 1-10). Mittleman (1942, *op. cit.*, 21: 101-5) thought that Bailey's specimens were intergrades between *E. l. guttolineata* and *E. l. pernix*. Thus, additional specimens from northern Georgia are of interest.

On June 22, 1952, two specimens (RLH 1020-21) of *E. longicauda* were collected in the Cumberland Plateau at the mouth of Sitton's Cave, Dade County. Comparisons were made with specimens of *l. longicauda* and *l. pernix* from Pennsylvania, Ohio, Indiana, and Kentucky and with specimens of *l. guttolineata* from the Coastal Plain of Georgia. The Dade County specimens were indistinguishable from typical *l. longicauda*. They showed no trend toward either *l. pernix* or *l. guttolineata*. Another specimen (RLH 750), collected at the Toccoa Experiment Station near Margret, Union County, in July, 1950, was also compared with typical *l. longicauda*, *l. pernix* and *l. guttolineata*. It has the dorsal and ventral pattern of *l. longicauda* and also the black stripe on either side as in *l. guttolineata*. Then, too, its lateral markings are much like those of *l. guttolineata*, but the vertical black bars are more widely separated. Consequently this specimen is regarded as an intergrade between *l. longicauda* and *l. guttolineata*.

In the southeast, *l. longicauda* inhabits the Cumberland Plateau and the Ridge and Valley Province. It meets and intergrades with *l. guttolineata* at the southern end of the Blue Ridge Mountains and the Ridge and Valley Province. Of course, intergradation may also occur at other places as yet unknown to us.

The Dade County specimens were taken in association with *E. lucifuga*. There is no sign of intergradation here between these two forms as has been reported by Mittleman (1942, *op. cit.*, 21: 101-5) to occur at other localities common to both.

Eurycea lucifuga Rafinesque.—The following are the first records of the cave salamander for Georgia. In June, 1952, thirteen specimens were taken in Case Cave and in Sitton's Cave, Cloudland Canyon, near Trenton, Dade County. Also, on February 20, 1954, four were taken at Wise Cave, near Rockmart, Polk County, the southernmost record for the species. In total length the specimens range from 82 to 143 mm. Six individuals in the series taken near Trenton contain eggs, the approximate diameters of which vary according to the individual female as follows: 2.9, 1.6, 1.2, 1.0, 0.7, and 0.6 mm. This differential in egg size may indicate that the breed-

ing season is extensive. Only one specimen contained recognizable food, a caterpillar about 40 mm. in length. Those taken in Wise Cave were very slender, perhaps an indication that food is especially scarce during the winter months.

Pseudacris brachyphona Cope.—This species has not hitherto been reported from Georgia, the nearest records being from the Cumberland Plateau in Tennessee and northern Alabama. It has not been recorded east or south of the Ridge and Valley Province. On March 6, 1952, 10 males were collected in a small pool on the slopes of Mount Oglethorpe, Pickens County, at an elevation of 2,500 feet. No females were found, but eggs were present in the pool. Forty-nine specimens, including five females, were collected in breeding choruses between February 21 and March 24, 1954, from the following places: Amicalola Falls, Dawson County; 10 miles southeast of Ellijay in Gilmer County; one mile north of Wier, Lumpkin County; and two miles east-northeast of Blue Ridge, Fannin County. In addition to the above mentioned collections, vocal records were taken in 1954 in the following counties: most of Fannin, the western parts of Union and Lumpkin, the northwestern half of Dawson, the northeastern part of Pickens, and the eastern third of Gilmer. Most specimens were calling from small heavily vegetated ponds or from pools of standing water in wooded areas as well as in open fields. Others were in roadside ditches, along the edges of lakes, or along the quieter pools of mountain streams.

The frog most closely associated with *P. brachyphona* in the breeding areas is *Hyla crucifer*, a form with a somewhat similar dorsal pattern. Several *Bufo terrestris americanus* and a few *Rana pipiens* were also collected near and among chorusing *brachyphona*. The relationship of *P. brachyphona* to *P. nigrila feriarum* is of particular interest. It has been observed repeatedly that in the extreme southern and eastern parts of the range of *brachyphona* in Georgia, both forms may call from the same general area; however, a little farther up into the hills (less than a half mile away) only *brachyphona* has been located, and a little farther down in the lowlands, only *n. feriarum*. The sharp line of separation in the occurrence of these two forms is very impressive.

Our Georgia series of *P. brachyphona* was compared with 13 males from Murphy, Cherokee County, North Carolina, and 11 from the summit of Big Black Mountain, Harlan County, Kentucky. In addition, they were compared with descriptions of *brachyphona* (Walker, 1932, Ohio Jour. Sci., 32: 379-84; Wright and Wright, 1949, Handbook of frogs and toads). One significant difference was noted. Walker stated that 25 percent of his specimens had the dorsal stripes fused. In the above-mentioned specimens, including those from Ken-

tucky, about 50 percent had the dorsal stripes fused, forming either a cruciform or a U-shaped marking.

We are grateful to William Cross, Charles Durrant, James Harrison, Buddy Robert, and Donald C. Scott for assistance in collecting specimens; to Norman Hartweg for loan of specimens of *Eurycea longicauda longicauda* and *E. l. pernix*; to Charles F. Walker for confirming the identification of the original series of *Pseudacris brachyphona* collected in Georgia; and to Albert Schwartz for the loan of specimens of *P. brachyphona* collected in North Carolina and Kentucky. Furthermore, we are grateful for the financial aid received from the Wildlife Conservation Fund of the University of Georgia.—BERNARD MARTOF AND ROBERT L. HUMPHRIES, Department of Biology, University of Georgia, Athens, Georgia.

A ROCK IN THE INTESTINAL TRACT OF THE SNAKE *HYPSIGLENA*.—A spotted night-snake, *Hypsiglena torquata ochrorhyncha* Cope, was collected by the writer on the afternoon of April 14, 1954, about one mile southwest of Yarnell, Yavapai County, Arizona. The snake was uncovered by prying a granite flake from the parent boulder. It was placed in a sack and later transferred to a gallon jar to which had been added cholla cactus debris but no rock or soil aside from the adhering dust. It was kept in this container in the laboratory until June 19. About a month after the date of collection a solid mass was detected in the snake posterior to mid-body. This mass was palpable for a short distance forward and backward, but tended to return to its original position.

On June 19 the snake was preserved. It had not been fed during the two months of its captivity and the mass had become more conspicuous. Its center was located approximately 50 mm. anterior to the anus. Total length of the snake was 342 mm.; snout-vent length, 292 mm. A ventral incision through the body wall and stomach disclosed a sharply pointed, irregular piece of granite, measuring 6.6 mm. long, 5.3 mm. wide and 4.9 mm. thick. The greatest diameter of the snake was 7.3 mm., at midbody. The dorso-ventral body diameter was 6.4 mm. immediately cranial to the mass and 4.6 mm. caudad to it. This marked tapering suggests that the artifact may have been acting as an intestinal obstruction. All measurements were taken on the fresh alcoholic specimen (deposited in the Museum of Vertebrate Zoology as No. 60828).

The fact that a granitic fragment was involved and that there was no exposure to food in captivity supports the belief that ingestion took place in the wild. It is conceivable that the rock was engulfed along with some normal food item such as a lizard. In California the writer found *Uta stansburiana stejnegeri* in the stomach of *Hypsiglena torquata de-*

serticola, and Cowles (1941, COPEIA (1): 4) recorded *Xantusia vigilis* and scorpions as natural foods. To suggest that the prey had swallowed the object before being attacked is begging the question, of course, and creates a yet more perplexing puzzle. It would be more plausible to suppose that the prey took up the piece during the death struggle. An alternate hypothesis is that the rock fragment had been rendered attractive through contact with an acceptable food item. It is common knowledge among those who maintain collections of live snakes that items not normally included in the diet are sometimes ingested. C. B. Perkins of the San Diego Zoological Society (personal communication) once induced a *Thamnophis* to swallow a piece of lettuce by adding to it the scent of fish. Gans (1952, Zoologica 37: 214-5) discussed food recognition in egg-eating snakes that occasionally swallow artificial nest eggs; he stated, "Once having started to feed, snakes will ingest subsequent food items indiscriminately. . . ." The supposition that the artifact in question was associated with a normal food item is favored by the fact that it remained in the gastrointestinal tract for over a month (certainly) after having passed through most of it.

It may be suspected that this snake did not regurgitate the ingested rock because it was unable to do so. Gans (1953, Herpetologica, 9: 153-4) suggested that the wooden nest egg, reported by Smith (*Ibid.*; 93-5), was irregurgitable because it had become too greatly swollen. Obviously, this explanation is inapplicable here, for a non-expansive piece of granite is involved. It may be that the size of the irregularly shaped flake and the sharpness of its edges made impossible its regurgitation and halted passage through the intestinal tract.—ROBERT GLASER, Museum of Vertebrate Zoology, University of California, Berkeley, California.

NOTES ON THE YOUNG OF SOME NORTH AMERICAN REPTILES.—In recent years I have had rather unusual success in obtaining gravid females of a number of native reptiles. Several of the litters produced by these represent maximum numbers for their respective species and the rest are of interest from other standpoints. A review of the literature reveals a surprising paucity of information on incubation periods, late and early dates of birth in the ovoviviparous species and measurement of litters. It is with the hope that further interest in this rather neglected phase of herpetology will be stimulated, that the following data are submitted.

I am most grateful to Dr. Edward S. Thomas, Curator of Natural History at the Ohio State Museum where this project was undertaken, for his helpful suggestions and for providing me with the time and working space which were required.

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of the usual laboratory routine and no detailed records were kept other than dates of birth or oviposition and hatching. Some of the young reptiles were preserved within a short time after birth, while others were induced to take food for varying lengths of time.

My hatching medium differed slightly from others with which I am familiar. Sphagnum moss was first saturated with water and then wrung out thoroughly. This was separated, shaken out and mixed with equal portions of sand and coarse shavings from the museum shop. Some of this material was placed loosely in the bottom of a low, wide-mouthed, one-gallon pickle jar to a depth of about one inch. The eggs were placed in layers well separated from each other by more of the mixture, and the jar was then filled almost to the top with loosely packed material. The top was covered with a one-pound coffee can which barely slipped over the mouth of the jar. Small amounts of water were added weekly. The laboratory temperature remained fairly constant at about 70° F. throughout the incubation periods.

Unless otherwise stated, I personally collected the reptiles discussed below. All of the material has been deposited in the Ohio State Museum (OSM) collection.

Sceloporus undulatus hyacinthinus (Green).—Zaleski State Park, Vinton County, Ohio; May 30, 1950. On the night of June 23, 11 eggs were laid on dry sand. These were transferred to the hatching medium. An embryological series was attempted with these eggs. Beginning about one week after incubation had started, one egg was opened each week until the final egg hatched normally on September 19 (incubation period 88 days).

Elaphe vulpina gloydi Conant.—Winous Point, Ottawa County, Ohio; April 15, 1951; collected by C. Eugene Knoder and Ralph Andrews. Nine eggs laid on July 16, all of which hatched on September 21 (incubation period 67 days). Nine days after hatching, these snakes each ate a small mouse. Since they were preserved at various times, measurements would have been of no significance. The female (length, 149 cm.) and two of the young were not preserved. 7 young. (OSM 968:1-7).

Storeria dekayi (Holbrook).—Bluffton, Ohio; July 11, 1950. On August 8, 1950, gave birth to 22 normal young, all of which were born alive, and a monster, having two bodies with a common head, which was born dead. The head of this snake was of normal size and scutellation, but the bodies were less than half the size of those of the rest of the litter. The normal young ranged in size from 87 to 100 mm. in length (av. 95.6). The maximum number among 14 litters reported by Schmidt and Davis (1941, Field book of snakes) was 20. Length of female, 242 mm. (OSM 948:1-24).

Thamnophis sirtalis sirtalis (Linnaeus).—Broward County, Florida; December 28, 1951; Howard V. Weems, Jr. Very emaciated when received. On January 11, 1952, gave birth to 36 young. A rather cursory examination of the literature failed to disclose any records of this species normally bearing a litter in midwinter, even in the latitude of southern Florida. The young were all born alive and were quite normal in every respect although averaging slightly longer than any which I have heretofore examined. They ranged in length from 202 to 227 mm. (av. 211 mm.).

The female died the day after the young were born and she and all of the brood were immediately measured and preserved. The total length of the female was 1167 mm. (46 inches), which is just one inch short of the maximum length reported for this species (Barton, 1952, COPEIA (3): 190-1). (OSM 969:1; 969:2-37).

Sistrurus catenatus catenatus (Rafinesque).—Cedar Swamp, Champaign County, Ohio; August 2, 1951. On August 11, 1951, gave birth to six living young, and three undeveloped embryos. These young fed readily on small white mice and were kept alive in the laboratory for several months. No measurements taken. Length of female, 565 mm. (OSM 971:1; 975:1-5).

Crotalus horridus horridus Linnaeus.—South Bass Island, Lake Erie, Ohio; May 13, 1951. On September 12, 1951, gave birth to ten living young, two still-born but perfectly developed individuals and one undeveloped embryo. Most of these fed readily on young white mice. No measurements were taken of the young. Length of female, 1,207 mm. (3 feet, 11.5 inches). This specimen is $\frac{1}{2}$ inch longer than the maximum Ohio record (Conant, 1938, The reptiles of Ohio). Excluding the one undeveloped embryo, these 12 young equal the maximum for this subspecies as far as I am able to ascertain. (OSM 972:1-12, 973:1).—CHARLES A. TRIPLEHORN
Department of Entomology, Cornell University,
Ithaca, New York.

OBSERVATIONS ON THE NATURAL HISTORY OF THE BAHAMAN PIGMY BOA, *TROPIDOPHIS PARDALIS*, WITH NOTES ON AUTOHEMORRHAGE.—During the latter halves of December, 1950 and 1951, Dr. Vladimir Walters, while working at the Lerner Marine Laboratory on Bimini Island, Bahamas, B.W.I., obtained 12 specimens of *Tropidophis pardalis* for the senior author, who deposited seven of them in the American Museum collections (AMNH 73501-05, 73708, 73542). These were found beneath flat stones near the seashore. One (AMNH 73501) was found on North Bimini and the others on South Bimini. In the series at the American Museum of Natural History there is evident ontogenetic change in the

dorsal pattern. Two young specimens (135 and 198 mm. snout-vent length) are marked by distinct dorsal blotches and much lighter ground color, and the posterior two-fifths of the tail is yellow. In intermediate sized specimens (255, 278 and 285 mm.) there is a marked tendency toward obscuration of the dorsal blotches by a darkening of the ground color and of the dorsal portion of the tail so that it, too, resembles the body ground color. The largest individuals (325 and 370 mm. snout-vent length) have a still darker ground color, gray or brown, that completely obscures the dorsal body and tail patterns. The dorsal pattern of the largest snake is distinctly different from that of individuals of equal length from other Bahaman islands. That more than one subspecies is involved is considered unlikely in view of the nature of the change in color pattern. Bailey (1937, Proc. New England Zool. Club, 16: 41-52) indicated that there is geographic variation in the tail coloration of this species. There is also considerable variation in tail color in our small sample of the Bimini population. One snake (AMNH 73542) has a solid black tail, both dorsally and ventrally, as in *T. p. curtus* of New Providence and *T. p. androsi* of Andros Island. In another individual (AMNH 73708) the tail is dark dorsally and there is yellow on the ventral surface, as (apparently) in *T. p. greenwayi* of Ambergris Cay, *T. p. canis* of Great Inagua, and *T. p. barbouri* of Long Island. The juveniles and one intermediate sized specimen have the last 40 percent of the tail yellow. The dorsal pattern of the individual of intermediate size has begun to change to the typical adult condition. It was noted in keeping these snakes that the tail was usually held in an exposed and erect manner. This may be an example of aposematic or perhaps flash coloration in the young. Several of the specimens have part of the tail amputated, and in one of the largest individuals (AMNH 73504) the entire tail is missing from a point just behind the anus. This high frequency of tail amputation may reflect the activities of a visually oriented predator, such as a land crab. Since these snakes are secretive and nocturnal, it seems improbable that the brightly colored tail could be used to attract food. In captivity these snakes were offered insects, young mice, frogs, and lizards. Of these, only small lizards were chosen. Young *Anolis* were readily accepted and small *Sceloporus* less readily. The snakes fed only at night. The prey was held usually in tight coils around its thorax and constricted. A small anole which was held a short time in the coils did not recover after being released. Rarely, some of the snakes did eat dead anoles. The food preference of this species in captivity is in marked contrast to its supposed close relative, *T. melanurus*, which takes a much wider selection of food in confinement and in the wild.

The senior author on a recent visit to the Exuma chain of the Bahamas found that the name "thunder snake" was applied to *T. pardalis*, apparently in reference to the fact that the local people generally note that it is most abundant after heavy rains. They also say that it is frequently found in the vicinity of, or actually in wells, an observation in accordance with experiences of one of the present authors in Jamaica. This is further corroborated by Campbell (1951, Nat. Hist. Notes of Nat. Hist. Soc. of Jamaica, 51: 55) who noted that the wood, water or thunder snake of Jamaica (*Tropidophis maculatus jamaicensis*) is reported often as being found in water tanks or wells and that it is an excellent swimmer. In the Bahaman wells there is an abundance of young *Hyla septentrionalis*, and it might be that the snakes are in search of them. If so, the apparent exclusive preference of the Bimini *Tropidophis* for lizards may be peculiar to that island population or to the individuals studied.

Upon being handled, *Tropidophis* rolls itself into a small, tight, compact ball of coils with the head placed in the middle of the ball. It remains in such a position as long as there is movement in the immediate vicinity. Inversion of the ball results in the snake rearranging its coils so that the ventral surface is again lowermost. The ball itself does not change position. This pattern of behavior was expressed by all individuals and has been recorded for other species in the genus, i.e., *Tropidophis semicinctus* (Darlington, 1927, Bull. Antivenin Institute (2): 59), and *T. maculatus jamaicensis* (Stull, 1928, Occ. Pap. Mus. Zool. Univ. Michigan, 195: 13; Underwood, 1952, Nat. Hist. Notes Nat. Hist. Soc. Jamaica, 53: 99).

Walters found that his first specimen of Bimini *Tropidophis* developed red eyes and bled freely from the mouth region when caught. During the first few weeks of captivity all the snakes showed clouded eyes and bled freely upon handling. This pattern of behavior decreased after the third or fourth week and could only be elicited by rough handling or by inflicting injury, particularly to the posterior portion of the body. The blood exuded freely from the mouth and nostrils and did not clot on the observer's hands.

A similar observation was made by Darlington (1927, *op. cit.*) in *T. semicinctus*. Stull (1928, *op. cit.*) noted similar behavior in a *T. melanurus* which was being anesthetized. Underwood (1952, *loc. cit.*) in reference to *Tropidophis maculatus jamaicensis* stated, "It seemed to have trouble sloughing, however, and after looking out of condition for several days I tried to help it off with its skin. It was impossible to avoid handling it somewhat roughly, for the skin on the head was adhering. I noticed that the space between the spectacle and the eye filled with blood. I covered the snake with moist cotton wool

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and tried again the following day with the same result. A few days later the snake died. I have had the same sloughing trouble with another wood snake." Campbell (1951, *op. cit.*) noted that the wood snakes of Jamaica bled profusely from the mouth and nostrils when chloroform is applied. Lewis (see Campbell, 1951, *op. cit.*) noted that specimens of *Tropidophis parkeri* (apparently a close relative of *T. melanurus*), upon removal from the snake bag, had left blood on the observer's hand; yet no injury could be found on the observer or on the snake. Carvalho (1951, *Revista Brasil. Biol.*, 2: 240) noted bleeding in some *Tropidophis paucisquamis* that were feeding and competing for the same food. He believed that this was due to the breaking of teeth, but it appears to us that it was a manifestation of the same phenomenon found in other species of the genus.

The specimens from Bimini were closely observed for the bleeding phenomenon. It was noted that, prior to the appearance of blood at the mouth or nostrils, the eyes turned ruby red as if a red shade had passed over them. As Underwood had previously indicated, blood passed between the spectacle and the eye. The shade-like effect is only of momentary duration. Walters and Ramm, holding a snake with its jaws open, under a binocular microscope, and stimulating the posterior portion of the body, induced the bleeding reaction and observed the entire process. It was noticed that two longitudinal blood vessels in the roof of the mouth became enlarged after stimulating the snake, and at the level of the internal nares free blood appeared on the palate and obscured further observation. Evidently the source of the blood is from the roof of the mouth and the blood release mechanism is under nervous control. Walters and Ramm took samples of the blood from the mouth and tail of AMNH 73542 and placed them in capillary tubes. After 30 minutes the mouth blood had not clotted, whereas after 10 minutes the tail blood had jelled but had not formed fibrin threads. Erythrocyte counts made from the tail blood averaged 501,000 r.b.c. per cubic mm. Blood taken from the mouth averaged 409,500 r.b.c. per cubic mm., an indication of dilution with saliva. The dilution is further indicated by changes in pH and cell volume size. The average pH of the tail blood was 7.3 (range 7.24-7.35), whereas the samples from the mouth averaged 6.96 (range 6.76-7.24). Mouth blood was injected into a large *Anolis carolinensis* with no apparent effect. The area around the injection site turned from green to brown and showed some swelling, but there was no definite indication of a toxic effect of the blood. Samples of the mouth and nostril blood were mixed with blood from *Rana pipiens*; the blood taken from the snake's mouth brought about both coagulation and hemolysis, whereas that from the nostrils in-

duced a mild hemolysis only. The experiments could not be continued because no more snakes were available.

In conclusion it can be stated that there is no apparent toxic effect of the blood on prey and that there seems little adaptive value of this peculiar mechanism to the feeding of the snake. Perhaps the non-coagulated mouth blood makes the snake distasteful to its predator or tormentor, and is analogous in value to its own anal exudations.—MAX K. HECHT, *Department of Biology, Queens College, Flushing, New York*, VLADIMIR WALTERS, 2836 Decatur Ave., New York 58, N. Y. and GORDON RAMM, *Department of Zoology, University of Maryland, College Park, Maryland*.

ON THE NORTHERN LIMITS OF THE SALAMANDER *NECTURUS MACULOSUS*.—

In a forthcoming review the senior author will discuss the identification, distribution and evolution of the species and subspecies of the genus *Necturus*. The senior author has examined about 3,000 specimens from over 350 localities, but despite this, certain areas within the geographical range of the genus remain unknown. In particular we have in mind the real northern distributional limits of the mudpuppy, *Necturus maculosus*. This species ranges throughout the Mississippi drainage east of the 99th meridian, the Great Lakes drainage, Hudson drainage, the Connecticut River and possibly the Susquehanna River. In the east the northernmost records are from the Great Lakes basin: Carleton Co., Ontario and Jacques Cartier and Ottawa Cos., Quebec (St. Lawrence drainage at about 46°N). In the western Great Lakes basin the mudpuppy is known from Thunder Bay Co., Ontario, on the north shore of Lake Superior at about 48°N. Two specimens are known from the Red River of the North drainage: United States National Museum No. 7007 from Lake Winnipeg, from about 51°N, and Minnesota Museum of Natural History No. 933 from Norman Co., Minnesota, about 48°N. The Red River of the North specimens seem to constitute the most westerly and the most northerly records. These records are important from the distributional standpoint because the Red River of the North flows into Hudson Bay. The physiological requirements of *Necturus* are the same as those of a primary division freshwater fish (Myers, 1938, *Smithsonian Rept.*, 1937: 339-64). For zoogeographical purposes *Necturus* should be considered more an ichthyological rather than a typical urodelan problem.

Students of Pleistocene drainage patterns have often pointed out that at the fullest extent of the Wisconsin ice cap the drainage pattern in the Manitoban-Dakotan region was southward into the Missouri and Mississippi rivers (Flint, 1947,

Glacial geology and the Pleistocene Epoch). As the ice sheet retreated northward and as Hudson Bay opened up, there was a drainage reversal so that the Red River of the North flowed through ancient Lake Agassiz into Hudson Bay. Thus many species of fish and *Necturus maculosus*, now found in the Hudson Bay drainage, may be traced to a Mississippi Valley origin. An examination of the Glacial Map of North America (Flint, 1945, Geol. Soc. Amer. Spec. Pap., No. 60) indicates that Lake Athabaska, Great Slave Lake, Great Bear Lake, and others were associated with the old Lake Agassiz drainage. It therefore comes as no surprise that a number of fishes of Mississippian source are known from Great Slave Lake, Great Bear Lake and the Mackenzie River. Rawson (1951, Jour. Biol. Bd. Canada: 207-40) listed the following from Great Slave Lake: *Amphiodon alosoides*, *Platygnathus gracilis*, *Notropis hudsonius*, *Notropis atherinoides*, *Percopsis omiscomaycus*, *Stizostedion vitreum* and *Cottus ricei*. In addition, Wynne-Edwards (1952, Bull. Fish. Res. Bd. Canada 94: 28 pp.) listed *Pyrilla neogaea* from the Mackenzie River. Two, *Percopsis omiscomaycus* and *Stizostedion vitreum*, are also known from Great Bear Lake. All the others also occur in the Mackenzie River. Other fishes listed by Rawson and Wynne-Edwards may be included but we have selected only those that indicate a Mississippian source since they are absent from Pacific Slope waters, none are known from Alaskan waters, none may be considered glacial marine relicts, all are primary division fishes, and all are known today from the Mississippi valley and/or the western Great Lakes basin. (Wynne-Edwards erroneously included southeastern Alaska in the range of *Cottus ricei*). The junior author has in press a paper dealing with the relationships between these and other elements in the Arctic ichthyofauna.

The genus *Necturus* is primarily a cold-adapted type. Logier (1953, The frogs, toads and salamanders of eastern Canada) and others have already pointed out that the mudpuppy is most active during the cold winter months. About 90 percent of the adults in museum collections were obtained between the months of December and April, and were taken on hook and line. None of the specimens examined that were collected during the months of June, July, August and September shows any evidence of having been taken by that method. It is well known that in northern regions the mudpuppy is often caught by fishermen on the larger lakes and rivers, through holes in the ice. It may therefore be concluded that low water temperatures are not a limiting factor in the northward distribution of *Necturus maculosus*.

Since the above-mentioned eight fishes are known from Great Slave Lake, Great Bear Lake, and the

Mackenzie River, it seems to us that the eventual discovery of *Necturus maculosus* is to be expected there. That region is not generally fished with hook and line during the winter months and it may be that the lack of collecting at this opportune time of the year accounts for the absence of mudpuppy records. Specimens from this northern region are urgently needed in order that they may be checked for certain indicated clinal trends that are present in *Necturus maculosus* and in the genus as a whole. It is hoped that this article will call attention to the acute need for specimens from this area; Great Slave Lake lies north of 61°N, at least 700 miles farther than the northernmost locality (Lake Winnipeg) for the species.—MAX K. HECHT, Department of Biology, Queens College, Flushing, and VLADIMIR WALTERS, 2836 Decatur Ave., New York 58, New York.

RECORDS OF THE SPADEFOOT TOAD, *SCAPHIOPUS BOMBIFRONS*, FROM ARIZONA.—During the summer of 1946 Messrs. Apollo and Plato Taleporos, Edward A. Williams, and I collected reptiles and amphibians in Baja California, Sonora, and Arizona; a few were also taken in New Mexico and southern California. It was not considered worthwhile to publish anything concerning our collections until Shannon (1953, Herpetologica, 9: 127-8) erroneously said our record of *Scaphiopus bombifrons* came from Chihuahua, México instead of from Arizona. He mentioned examining other Chihuahua specimens collected by us and now in the collections of the American Museum of Natural History (AMNH). None of us has ever visited Chihuahua and no specimens from that region are accredited to us.

We caught one individual of *S. bombifrons* during the entire trip (AMNH 53058); the others listed by Shannon as *S. bombifrons* are actually *S. couchi* (AMNH 53060-2). These toads were collected the night of July 21; we had started from Punta Penasco, Sonora, early in the evening, and had headed north for Gila Bend, Arizona. Heavy rain was encountered a short distance south of the Arizona-Sonora border and showers were met with, on and off, throughout the night. Spadefoot toads were collected on the highway between Ajo and Gila Bend. In addition to the above-mentioned specimens of *S. bombifrons* and *S. couchi*, one *S. hammondi* (AMNH 53059) was also caught by us.

Shannon should have realized that finding *S. bombifrons* at three additional, widely scattered, localities in southern Arizona (Willcox, Lowell, Charleston) substantiated our original "first" record for the species in the state. As for the observed differences between our specimen and Shannon's three, it is entirely possible that all four Arizona individuals belong to the same form

of *S. bombifrons*. Since there is only one specimen from each locality, the significance of these differences cannot be satisfactorily evaluated.—VLADIMIR WALTERS, 2836 Decatur Ave., New York 58, New York.

NOTES ON SALAMANDERS FROM WESTERN CONNECTICUT, WITH ESPECIAL REFERENCE TO *PLETHODON CINEREUS*.—The most comprehensive work dealing with the Amphibia of Connecticut (Babbitt, 1937, Bull. State Geol. Nat. Hist. Surv. Connecticut: 50 pp.) describes and illustrates 13 kinds of salamanders. Included are the mud puppy, an introduced species, and the slimy, red and purple salamanders; the latter are found near the borders of the state but have not been definitely recorded in Connecticut. Also, the tiger salamander has not been found indigenous to the state, although it has become established around New Haven. This leaves nine species that are definitely native to Connecticut.

The records cited by Babbitt from western Connecticut are mainly from Salisbury, Lakeville and Bear Mountain, with a few from Washington, Norfolk and Kent, all of which are in the western part of Litchfield County. The records given herein are new to eastern Litchfield County or are additional records from its central and western parts.

During the years 1953 and 1954, five trips were made to Litchfield County by the author. Enough new records were accumulated to warrant this note about them. The specimens cited were collected by the author, unless otherwise indicated, and are in his collection. Unless otherwise noted, the dates refer to collections made in 1953.

Ambystoma maculatum Shaw. Spotted salamander.—One large specimen was collected from under a large rock, on Highland Lake, Oct. 17. This species seems to be plentiful along the Mad River, which flows through Winsted, according to several reliable observers. Babbitt listed it from only one other place in this county: Salisbury, July 15, 1928 (by W. Hamilton).

Desmognathus fuscus fuscus Rafinesque. Dusky salamander.—This salamander is quite common throughout the county. The following specimens (numbers in parentheses) were collected: along Mad River near Winsted (8), May 17; Burr Pond (1), May 16; Lime Rock (1), May 17; Highland Lake (9), July 15; Haystack Mountain near Norfolk (3), Oct. 17; Norfolk (1), Oct. 17. The collections of Babbitt are all from farther west in the county than mine, his being from Lakeville, Salisbury, Kent and Washington.

Eurycea bislineata Green. Two-lined salamander.—This salamander is also quite common, especially along the streams and in swamps around lakes. Mad River near Winsted (2), May

17; Highland Lake (8), July 16 and Oct. 17; Bakersville (3), Oct. 18; Lake Waramaug near New Preston (4), Oct. 18; Canaan (10), Oct. 17. Babbitt's collections of this salamander are from Kent, Lakeville and Salisbury.

Hemidactylium scutatum Schlegel. Four-toed salamander.—This little salamander is rather rare in Connecticut. A single specimen was collected in a sphagnum swamp around the edge of Burr Pond, near Burrsville, Oct. 18. Babbitt mentioned two collections from the northwestern corner of the county, collected in 1926 (Bear Mt.) and 1928 (Lakeville).

Diemictylus viridescens viridescens Rafinesque. Newt or red eft.—This is the most common salamander in Connecticut. Three life-forms were found. West Hills Lake (4 newts, common in lake), May 16; Highland Lake (3 efts, under rock and logs), July 16 and Oct. 17; Burr Pond (10 newts, common in lake), April 5; Canaan, in pond in pasture (9 newts, aquatic; 4 newts, terrestrial), Oct. 17.

Plethodon cinereus cinereus Green. Redback salamander.—In the specimens collected by the author in western Connecticut there are three rather distinct color phases: the ashy or leadback, the redback, and a nearly all red type which I designate as scarlet. Since Lakeville and Salisbury are the only places mentioned by Babbitt from which specimens of this species are recorded, all of my records represent new localities.

The ashy or leadback phase is quite uncommon in northwestern Connecticut. Of over 100 specimens of *P. c. cinereus* taken from this area, only two are of this type. Both came from the Highland Lake region, one collected from inside a log on October 17 and the other from under a log on April 17, 1954. Matthews (1952, COPEIA (4): 277) did not find any individuals of this phase around North Colebrook.

The redback phase is common in suitable woody areas and is found only rarely in open fields in this region. In central Connecticut, both the red and lead phases have been found in about equal numbers, according to Babbitt. However, in northwestern Connecticut the red phase predominates. Some of the individuals have a distinct red stripe dorsally, but in many the red color is suffused over the head and along the sides, thus obliterating any distinct line along the margin of the stripe and constituting a truly "red-headed" redback form. The venter of all redbacks is mottled with black and white. Additional records from Litchfield County are: Highland Lake (85), April 5, April 16-18 (1954), May 16, July 15-16, and Oct. 17; Mad River near Winsted (1), May 17; West Hills Lake (1), May 16; Lake Waramaug near New Preston (2), Oct. 18; Bakersville (3), Oct. 18.

One specimen with a light creamy-white stripe was collected at Burr Pond near Burrsville on April 5. The stripe in many of the specimens taken on April 16-18, 1954, was a lighter red varying to orange and yellow-orange.

The scarlet phase is much more frequently encountered than the leadback. Individuals are unusually red, although they resemble northern individuals of the redback phase in most characteristics. They have the following distinguishing features. The entire head and trunk are red to coral-red or pink. The ventral surface is immaculate pink to coral-red, with no black and white mottling (a prevalent characteristic of the other phases). There is usually considerable black pigmentation in the distal part of the tail, with a few scattered black spots occurring over the body. The eyes are black, and there are 17 costal grooves. Twenty salamanders fitting this description have been collected in Litchfield County. They were found under rocks, in streams, under logs, in burrows in logs and under ground, under large boulders on sloping hillsides of birch, and around the edges of lakes in low ground. Locality records are as follows: Highland Lake, 800 ft. alt., 2 miles southwest of Winsted (15), April 5, April 16-18 (1954), May 16, July 16, Oct. 17; Burr Pond State Park or Reservation, 800 ft. alt., near Burrsville (5), April 17 (1954), and Oct. 17. Among those collected on Oct. 17 were three juveniles that measured 13 mm., 15 mm., and 15 mm. in total length; they were red with a brownish lateral line on either side, and had no black markings on the tail. By January, 1954, they had grown, on a diet of aphids, to lengths of 30 mm., 33 mm., and 35 mm., respectively, with no change in coloration. By May, 1954, two had lost parts of the tail; the one perfect specimen measured 42 mm., and a few black spots were beginning to appear on the terminal 4 mm. of the tail. By December, 1954, the perfect specimen looked exactly like the adults collected the year before (described above). Two juvenile specimens, collected on April 17, 1954 in the same area, measured 38 mm. and 41 mm.; the overall color was salmon-red with a brownish lateral line and no black on the tails.

At North Colebrook, also in Litchfield County, but just north of the localities studied by the author, Matthews (1952, COPEIA (4): 277) collected 16 specimens which fit the above description accurately and were described as being erythristic. He also found 54 redbacks but no leadbacks in the same area. At Sandy Brook, about 2 miles from North Colebrook, he found 11 individuals, all typical redbacks.

Other records of *Plethodon c. cinereus* which best fit the description of the scarlet phase have been reported from New York (Buffalo, Bessemers—

H. Reed, 1908, Amer. Nat., 42: 460; Chataqua—Reed and Wright, 1909, Proc. Amer. Philosoph. Soc., 48: 403; New Salem—Bishop, 1941, Bull. New York State Mus., 324: 200), Massachusetts (Cohasset—Barbour, 1914, COPEIA 10: 3-4; Amherst—Bartlett, 1952, Herpetologica, 8: 100), and New Hampshire (Andover—Burt, 1945, Trans. Kansas Acad. Sci., 48: 204). Thus, this color phase is truly northern, being found only in the northeastern part of the range of the species.

Individuals of the scarlet phase found by Matthews and by the author within a radius of 10 miles of Winsted, Litchfield County, Connecticut, now total 36. Natives of the region say that this phase is not uncommon in their rocky gardens and in the woods about their homes. Perhaps the results of breeding experiments, now in progress, will help in understanding the reasons for the existence of color ratio differences in the various populations.—CLYDE F. REED, 10105 Harford Road, Baltimore 34, Maryland.

TECHNIQUE FOR BLEEDING SNAKES BY CARDIAC PUNCTURE.—As a part of investigations concerned with the ecology of western equine encephalitis, it was considered desirable to obtain blood samples from certain snakes. This paper describes the techniques developed and used in obtaining blood samples from snakes during these studies. While holding the snake alone or with someone helping, it continuously twists and tries to escape, making it very difficult to obtain an adequate blood sample. In the following procedure, the snake is held in such a way that blood samples can be obtained easily and quickly.

The field sampling equipment, about the same as described by Sooter (1954, Jour. Wildl. Mgt.), consisted of a small box or burlap bag for holding the snake while preparing to take a sample; a supply of sterile 1- or 2-ml. syringes; sterile 1-inch, 27-gauge needles; small (10 cc.) serum bottle with 10 percent rabbit serum or horse serum in buffered saline diluting fluid (10 ml. of rabbit or horse serum in 90 ml. of Sorensen's buffered saline; rabbit or horse serum is inactivated at 56° C. for 30 minutes before adding to buffered saline solution); a bottle of 70 percent alcohol; tightly corked, sterile 10 × 75 mm. soft glass tubes with adhesive tape labels, for blood samples; and a pint thermos flask partly filled with wet ice for immediate refrigeration of blood samples and for carrying these to the laboratory. A bottle of clean water, for rinsing syringes and needles, facilitates later cleaning of this equipment.

A snake to be sampled was held firmly just back of the head by one hand and stretched out on its back on the ground near a shrub, fence-post or

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similar protuberance. It was then permitted to loop around the post or shrub by the posterior portion of its body and pull itself taut (Plate I). In the laboratory the snake can be looped around a table leg. A $1'' \times 4''$ board 3 feet long, with a 1-foot section of broom handle inserted at one end to loop the snake around, also has been found satisfactory. In working with experimental snakes, it was also found that the heart action is more noticeable and blood supply more easily obtained if the snake is warmed up in a heated room or in the sunshine before bleeding.

After the snake is stretched taut on its back, it is fairly easy to feel for the heartbeat along the ventrals with the index finger. Often the heartbeat can be noted by watching carefully the anterior one-fourth of the snake's ventral side. A snake, in pulling itself taut, tends to hold the heart in one place during the blood sampling activity.

The needle and syringe are set up with a small amount of diluent, and the needle is then placed about two ventrals back of the heartbeat for inter-ventral penetration into the body cavity at about a 45° angle towards the heartbeat (Plate I). As soon as penetration is made through the skin the aspiration action with the syringe is started. Penetration is made steadily and slowly so that sufficient time will be allowed for blood to appear in the tip of the syringe before the needle is pushed through the heart. From approximately 0.1 to 0.3 ml. or more of blood was taken from each snake according to its size. The blood obtained is placed in a sterile tube which is corked, labeled, and placed in a thermos of ice if in the field, or refrigerator if at the laboratory. This method of holding snakes can also be used in force-feeding or in inoculations with experimental materials.

The snakes sampled to date by this method include the bullsnake (*Pituophis catenifer*) and the gartersnakes (*Thamnophis radix* and *Thamnophis sirtalis*). Some of these have been bled nine times with no apparent ill effects.—CLARENCE A. SOOTER, *The Communicable Disease Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Greeley, Colorado.*

AN ABNORMAL CARAPACE IN THE SNAPPING TURTLE, *CHELYDRA SERPENTINA*.—A skeleton of the common snapping turtle (*Chelydra serpentina*) measuring 11 inches in length was collected at the Montezuma Migratory Waterfowl Refuge near Seneca Falls, New York. The carapace contained an extra dermal plate on the right side inserted between the fourth and fifth vertebral plates and the fifth and sixth costal plates (Fig. 1). This additional plate measured five-eighths of an inch in maximum width and one inch in greatest length. The sutures surrounding it

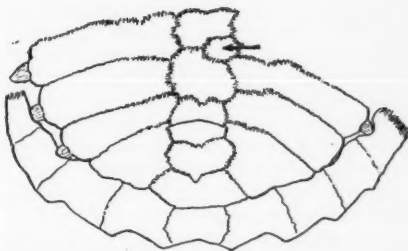


Fig. 1. Posterior part of dermal carapace of *Chelydra serpentina* showing anomalous plate (arrow).

were toothed and normal, and it evidently grew from an independent center of ossification and was not the result of an injury. The epidermal plates were normal in number and arrangement.

Since dermal plates normally arise metamerically and reflect bilateral symmetry, such an anomalous plate seems most unusual.—LEROY C. STEGEMAN, *State University of New York, College of Forestry, Syracuse, New York.*

THE SALAMANDER *SIREN LACERTINA* FEEDING ON CLAMS AND SNAILS.—The great siren, *Siren lacertina* Linnaeus, inhabits the Coastal Plain swamps of the Atlantic coast as far north as Maryland. In the northeastern limit of its distribution it appears to be quite uncommon; this is suggested by the fact that the U. S. National Museum collection contains only three specimens from Virginia, and few field workers have mentioned its discovery. On May 19, 1953 an adult (snout-vent length, 369 mm.) was caught in Indian Creek, a muddy stagnant ditch near Norfolk, Norfolk County, Virginia. The specimen was obtained by a fisherman, on a hook baited with an earthworm. The stomach of this specimen was obtained by R. H. Rageot of the Norfolk Museum of Arts and Sciences, and was later donated to the authors. It was noted that the stomach contained a moderate amount of filamentous algae and a large number of shells of mollusks. The fleshy parts of the mollusks had been digested away, but there was little evident erosion of the shells, and they were identified as follows: *Musculium jayense* (Prime), 120 specimens ranging in dimensions from 1.5×1.3 mm. to 9.5×8.2 mm.; *Helisoma anceps* Menke, 8 specimens (immature); *Physa heterostropha* Say, 5 specimens (immature); *Gyraulus hirsutus* (Gould), three specimens; and *Pseudosuccinea columella* Say, 2 specimens (immature). The smaller *Musculium* were embryonic, and most of them consisted of two complete, hinged valves; larger specimens frequently were found to have one valve fragmentary or missing. All of these mollusks are typical inhabitants of the stagnant water habitats frequented by *Siren*. Rageot (per-

sonal communication, July 2, 1954) stated that on subsequent field trips to the habitat he always found the water muddy or murky, suggesting that the salamander forages in a habitat where vision is a minimal factor in locating food items, and that feeding undoubtedly depends in large extent on the stimulation of Jacobsen's organ. It is our opinion that the algae were ingested incidentally.

Dunn (1924, Science, 59: 145) suggested that *Siren* is an herbivorous salamander, as the result of his examination of several stomachs containing nothing but filamentous algae, and his reasoning based upon the type of dentition and the elongated gastro-intestinal tract. Noble and Marshall (1932, Amer. Mus. Novitates 532: 1-17) observed *S. lacertina* in the laboratory devouring *Spirogyra* along with earthworms. Hamilton (1950, Nat. Hist. Misc., 62: 1-3) mentioned that snails are not as important in the diet of *Amphiuma* as they are in *Siren*, and that a large *Siren lacertina* often "contains a half a pint of snails, with the resultant debris of mud and vegetation fortuitously ingested when it eats these creatures."

Dunn (1924, loc. cit.) observed that amphibians have no food preferences and that what they eat is determined by size and availability; and that the food of the same species in different localities differs much more than the food of different species in the same locality. He explained this with the statement that salamanders in general do not vary much from a uniform structure or from an indiscriminating and carnivorous diet, and he cited *Siren* as an exception to this general rule. Recent observations by Behre (1953, COPEIA (1): 60) and Wood and Goodwin (1954, Jour. Elisha Mitchell Sci. Soc., 70(1): 27-30) on the common newt, *Diemictylus viridescens viridescens* Rafinesque, point out a selectiveness in feeding on mollusks. The presence of the large proportion of *Musculium* in the stomach contents of *Siren* is suggestive of selective feeding by this species.

Dunn mentioned that Linnaeus supposed that *Siren* eats snakes, and while this is not improbable, it has not been reported in the literature by recent observers; he added that Barton, in his letter to Schneider in 1821, stated that he fed his specimens on angleworms and pieces of meat, and that Hurter remarked in 1911 that *Siren* feeds on worms and minnows. LeConte (1824, Ann. Lyceum Nat. Hist., 1: 52-8) found nothing but mud in the stomachs of *Siren*. These observations include suppositions, observations on captive specimens, and stomach examinations, but they do raise some question as to the extent of selectivity in the feeding of *Siren* which cannot be answered until an extensive food habits survey is done. It is the opinion of the authors that the dentary modifications and the elongated gastro-intestinal tract could be adapta-

tions for a mollusk diet as readily as for an herbivorous one.

The studies to which these observations are incident were supported by a grant from the A.A.A.S. through the Virginia Academy of Science, to which groups grateful acknowledgment is hereby made.—PAUL RANDOLPH BURCH, *Redford College, Redford*, and JOHN THORNTON WOOD, *University of Virginia, Charlottesville, Virginia*.

MEASUREMENTS AND WEIGHT OF A PACIFIC LEATHERBACK TURTLE, *DERMOCHELYS CORIACEA SCHLEGELI*, CAPTURED OFF SAN DIEGO, CALIFORNIA.—An adult male Pacific leatherback turtle, *Dermochelys coriacea schlegelii* Garman, was captured near the Coronados Islands, southwest of San Diego, California, June 26, 1953, by Mr. Earl Larrobel of San Diego. The turtle was at the surface of the water when Mr. Larrobel gaffed it from the sport fishing boat REDWING; it was then towed to shore. We observed it on the dock at Point Loma shortly after capture and again the following day at the San Diego Fish Market, 915 West Harbor Drive, San Diego.

Measurements and weights were obtained through the courtesy of Mr. Larrobel and Mr. John S. Ghio, owner of the San Diego Fish Market. Measurements, all made in a straight line, are as follows (in mm.): total length, 2,130; carapace length, 1,440; carapace width, 970; width from front flipper tip to flipper tip, 2,351; greatest body depth, 630; head length, 245; head width, 237; greatest front flipper length, 843; greatest front flipper width, 298; greatest hind flipper length, 428; greatest hind flipper width, 268; tail length, 172; greatest tail width, 57; penis length, 493; greatest penis width, 96; head (ball) of left humerus, 62 × 85. The intact weight (768 lbs.) was obtained from the scales of the San Diego Fish Market. Estimates made prior to weighing ranged from 1,000 to 1,500 pounds. Thirty-one major tubercles projected along the midline of the carapace. The head, part of the neck, the penis, and part of the oesophagus are preserved in the collection of the Department of Zoology, University of Arizona.

The turtle was sold on the day of capture to Mr. Ghio for \$.05 per pound, intact. It was placed in the ice room of the market and butchered the following morning, June 27, 1953. Mr. Ghio was cautioned as to the edibility of leather-back meat. He said that he had been familiar with it for many years and considered it perfectly safe to eat, without any ill effects.—CHARLES H. LOWE, JR., *Department of Zoology, University of Arizona, Tucson, Arizona*, and KENNETH S. NORRIS, *Marineland of the Pacific, Marineland, California*.

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AN ALBINO MILKSLAKE, *LAMPROPELTIS DOLIATA TRIANGULUM*, FROM OHIO.—A female albino milksnake, *Lampropeltis doliata triangulum*, was collected with two normal adults in Etna Township, Licking County, Ohio, June 9, 1954. Mrs. George Page reported to the Ohio State Museum that she had first seen the albino on the 8th of June. Upon investigating the report, the authors found the three snakes under a cistern cover on the Page farm.

The albino has 7 upper labials, 8 lower labials, 1 preocular, 2 postoculars, 204 ventrals, and 43 subcaudals; the total length was $33\frac{3}{4}$ inches. The two normal specimens were $37\frac{7}{8}$ and $34\frac{3}{4}$ inches.

On the evening of June 21, the albino laid 11 eggs. The smallest of the eggs measured 31 mm. \times 15 mm.; the largest, 42 mm. \times 15 mm. The average dimensions were 34.0 mm. \times 16.1 mm. On June 23, one of the normal individuals laid 14 eggs. No measurements were taken, as they had shriveled somewhat before being discovered.

Of the 11 eggs of the albino, two hatched, one on August 10 and the other on the 12th, after incubation periods of 51 and 53 days, respectively. The two young snakes were normal and had the characteristic color pattern found in juveniles. They were 24.4 and 23.6 cms. in total length. The other eggs were opened and found to be infertile.

One of the eggs of the normal female hatched on August 1, after an incubation period of 52 days. The length of this snake was 23.5 cms. One other embryo broke through its shell, but never emerged, and finally died. One egg, opened on July 19, contained a fairly well developed embryo; the other 11 were found to be infertile.

Conant (1938, Amer. Midl. Nat., 20 (1): 70) stated that milksnakes ordinarily are not hardy in captivity. Our albino has taken three mice (as of August 26, 1954). Two mice were introduced into the cage containing the normal adults. One was struck immediately and swallowed. The other mouse evaded capture until after the first one had been eaten, and then it, too, was engulfed by the same snake that ate its companion. The luckless snake continually struck at and constricted the one that had fed. When its coils finally tightened around the part of the body containing the swallowed mice, we were afraid that suffocation would result and so we separated them. These specimens are all located at the Ohio State Museum.—JOHN M. CONNIT, Department of Zoology and Entomology, Ohio State University, and ROBERT E. WOODRUFF, Ohio State Museum, Columbus 10, Ohio.

ACCLIMATIZATION OF THE LIZARD *PHRYNOSOMA CORNUTUM* ON THE FRENCH RIVIERA.—Back in 1914-1915 M. Gury, a resident of Nice, France, brought home

living specimens of *Phrynosoma cornutum* Harlan from Texas. They readily adapted to the climate of the south of France, and eventually began to hibernate in a box of earth. Unfortunately M. Gury had the unlucky idea of digging them up in mid-winter to see if they were still alive, and the unseasonable awakening killed them.

Lately I have been following an involuntary experiment with these creatures. On July 8, 1952, about 150 *Phrynosoma cornutum* arrived at the Nice airport, consigned to the organizers of a "Texas Night" party at the Municipal Casino. In the course of the evening the lizards were given to various dancers, along with other souvenirs of Texas. A good many of the dancers seemed to have discarded them on the way home, either along the roadside or in gardens. Since then, several have been recaptured in the countryside; they were in perfect condition and have adapted completely to the climate of the Côte d'Azur. The most interesting thing about it is that some were captured after passing a whole winter at liberty. Between May and August, 1953, several fat and lively specimens were brought to me. Others were unfortunately killed by people who were frightened at encountering this spiny lizard. Specimens were captured or killed at Villeneuve-Loubet, Cagnes, Antibes and Eze.

I have at my home a fine specimen found at Villeneuve-Loubet in August of 1953. It fed voraciously up until sometime in November, eating mealworms, crickets and flies. It went underground at the end of November and at the moment (March 1, 1954) is still hibernating but is quite alive. I now hope to undertake a more voluntary and supervised experiment with the acclimatization of this interesting lizard in our area.—PIERRE BECK, Nice, France. (Communicated in French and translated by William Bridges, New York Zool. Park.)

AMPHIBIAN ADDITIONS TO THE GOLD COAST HERPETOFAUNA.—While it is possible that unrecorded Gold Coast examples of the undermentioned frogs may be present in some museum collections, none of them appears to have been reported in the literature. These are *Kassina s. senegalensis* D. & B., *Rana g. galamensis* D. & B., *Rana macCarthyensis* Andersson, and *Rana o. ornata* Peters. The first two were originally described from the vicinity of the Galam Lakes, Senegal; the third from MacCarthy Island in the Gambia River; while *ornata*, with East African specimens of which it has been compared, was from Teita (Taita), Kenya Colony. However, I have previously recorded *ornata* from French Equatorial Africa. As might be expected of such a fossorial species of the subgenus *Pyxicephalus*, the Gold

Coast specimen was taken in the more arid Northern Territories at Navrongo. The rest were captured at Achimota by Father M. C. Lesage, to whom goes the credit for this discovery in the country. As they formed half of the total number of species he submitted for identification, these records emphasize the neglected state of West African amphibiology.—ARTHUR LOVERIDGE, *Museum of Comparative Zoology, Cambridge 38, Massachusetts.*

NEW DISTRIBUTIONAL RECORDS FOR PHILIPPINE AMPHIBIANS.—In the conclusion of his paper on Philippine Amphibia, Dr. Inger presented a faunal list summarizing his distributional data (*Fieldiana Zool.*, 33(4): 183-531). Comparison of the data presented therein with the Stanford (SU) collection of Philippine Amphibia has revealed that several new records may be added to that list.

In a footnote to this appendix Inger stated, "The species in parentheses have not yet been recorded from the islands under which they are listed, but as explained (p. 462), it is highly probable that they occur as indicated." (*op. cit.*: 511). In this short note the author would like to confirm several of Inger's suppositions concerning the occurrence of previously unrecorded forms, and in addition add to the list several species that were not mentioned as even being possibly present in certain localities.

All specimens recorded herein, with the exception of the two from Samar Island, were collected by Dr. Albert W. C. T. Herre in the course of his 1940-41 Philippine expedition; the two exceptions were taken by Ralph F. Annereaux in 1945. Identifications were made by the author, with two exceptions: *Ichthyophis monochrous* and *Megophrys monticola stejnegeri* were determined by Professor G. S. Myers. Inger's nomenclature is followed in the list of new records given below.

Chaperina (cf) *fusca*—SU 14314-5; (probably Leyte City) Leyte Island; June, 1940.

Ichthyophis monochrous—SU 6065; Marata Bagan, Lanao Prov., Mindanao Island; August 18, 1940.

This species was previously known on Mindanao only from Davao Prov.

Kaloula picta—SU 9840; Cebu, Cebu Island; September 23, 1940. SU 14219-20; Iloilo, Iloilo Prov., Panay Island; August 5, 1940.

Megophrys monticola stejnegeri—SU 7268; Cebu, Cebu Island. This specimen was presented to Dr. Herre on Cebu in 1940, probably sometime in late July or early August.

Rana cancrivora cancrivora—SU 13943-4; Jolo Island, Sulu Archipelago; September 13, 1940.

Rana limnocharis (pultigeri)—SU 14695-704; (probably Leyte City) Leyte Island; August 1940.

Rana macronotus visayanus—SU 14718; Naga, Samar Island; June 2, 1945.

Rana signata (cf) *glandocula*—SU 14802; Salcedo, Samar Island; August 25, 1945.

Rhacophorus appendiculatus appendiculatus—SU 14750-4; (probably Leyte City) Leyte Island; June, 1940.

Rhacophorus leucomystax (linki)—SU 5939-42, 13969; Coron, Busuanga Island; June 22-30, 1940.

—ALAN E. LEVITON, *Natural History Museum, Stanford University, California.*

A DESCRIPTION OF THE EGGS OF THE CORAL SNAKE *MICRURUS F. FULVIUS*.—Although the coral snake, *Micrurus f. fulvius*, is generally considered as one of our better known snakes, little has been published on its life history. I have been able to locate only two references to its breeding habits. Ditmars (1936, The reptiles of North America) mentioned a clutch of seven eggs, from a large female, which was successfully incubated. He failed to describe the eggs, except to say that they were elongated. He did say, however, that the incubation period of this clutch was 7 weeks and that the size of the hatchlings was about 7 inches. Schmidt and Davis (1941, Fieldbook of snakes of the United States and Canada: 276) stated that two to four elongate eggs are produced, as indicated by females nearly ready for oviposition.

On June 11, 1953, I received a female *Micrurus f. fulvius* from a boy who had captured it in the Winter Haven area, Polk County, Florida. The snake was obviously gravid and so I put her in a gallon jar with an abundance of dried leaves and grass. On June 18, she deposited seven eggs. They were quite elongate, and had a smooth, creamy-white shell. Five eggs were stuck firmly together in one cluster, and two in another. The eggs, measured with a plastic millimeter ruler, were 36 mm. to 46 mm. in length, with a mean of 38.8 mm. Five of the eggs were 14 mm. in width and two were 13 mm., with a mean of 13.7 mm. The ratio of width to length is 28.2 to 38.8, with a mean of 35.5.

Unfortunately, I was in the field for 10 days during the incubation period, and the eggs became too moist and solidified. The female was 819 mm. (32¼ inches) in total length, and is SRT 717 in my private collection.—SAM R. TELFORD, JR., *University of Virginia, Charlottesville, Virginia.*

NOTES ON AN EXCEPTIONALLY LARGE WORM LIZARD, *RHINEURA FLORIDANA*.—Smith (1946, Handbook of lizards: 434) recorded the maximum length attained by *Rhineura floridana*, the Florida worm lizard, as 11¼ inches, or approximately 298 mm. A careful search of the available literature fails to disclose any additional comment on the maximum length of this species, although one writer, Ditmars (1936, The reptiles of North America) mentioned that the average length of adults is

about 8 inches. This average agrees completely with my observations on the score or so of lizards that I have collected during the past four years.

Thus, it was with considerable interest that I received an exceptionally large *Rhineura*, 15½ inches in length and ½ inch in diameter. It was caught by Mrs. Ann S. Telford during the morning of July 27, 1954, on the west side of Lake Shipp, Winter Haven, Polk County, Florida. The lizard was crawling on the surface of the ground, beneath the shade of a large oak tree. The soil of this locality is principally Leon sand, in contrast to the St. Lucie Fine sand of the usual local habitat, rosemary scrub. Possibly previous heavy rainfall, which created a sharp rise in the water table during the preceding two weeks, caused the lizard's emergence during daylight hours.

The individual is a male, and its tail comprises 7.3 percent of the total length (384 mm.). There are 249 rings of scales on the body, and 18 on the tail, which are normal counts for the species. The specimen has been deposited in my private collection as SRT 951.—SAM R. TELFORD, JR., *University of Virginia, Charlottesville, Virginia.*

THE APPLICATION OF X-RAYS TO THE STUDY OF SMALL REPTILES AND AMPHIBIANS—In the course of several quantitative studies on skeletal variation in reptiles and amphibians, radiographs have been found to be very useful supplements to cleaned or cleared specimens. Since our object was to measure radiographic images, special techniques were necessary to assure minimum distortion. It was felt that the procedures outlined here, although by no means completely original, might be of interest to other workers.

There are several advantages to the use of X-rays. Cleaned skeletons of small animals are subject to considerable deformation in de-greasing and drying and are therefore not wholly satisfactory for quantitative studies. Clearing and staining removes this objection but is tedious and time consuming. The X-ray method is fast, and valuable specimens are not sacrificed for skeletons. The method has a drawback in that quantitative comparisons are limited to between radiographs, and best between radiographs made only under similar physical circumstances. Further, the radiographic image is not equal in its dimensions to the object X-rayed, so that a distortion factor must be assessed and accommodated. It is to this latter objection that this writing is addressed.

Image distortion results from the nature of the X-ray projection itself and from the positioning of the object to be examined. Since X-rays obey the common laws of light, the control of their tendency to magnify is simply a matter of applied geometry.

The size of the image is to the size of the object, as the distance of the source from the film is to the distance of the source from the object. The law does not consider all the deviations from true shape in a radiographic image but for practical purposes is quite sufficient. Obviously, considering these conditions only, the minimum magnification will be obtained when the object is as close to the film, and the source is as far away, as is practicable.

When these physical conditions have been met satisfactorily, the chief source of image distortion will be from positioning. The least positioning distortion will be obtained when the plane of measurement is parallel to the recording surface and the object is centered directly beneath the target. Tipping of the object will reduce the size of the image. The farther the object is from the point directly beneath the source, the greater it will be magnified and distorted by reason of the law stated above. Actually the alignment of the long axis of the tube with respect to the alignment of the long axis of the object affects the size of the image, but the factor is so small that it may be disregarded.

Error, due to the object being at some distance off center, can be minimized by centering over that part of the animal being studied or, as with snakes, filming a small section at a time. Maintaining the plane of measurement parallel to the film is the most difficult requirement to be fulfilled since the object of interest is hidden from view. Particular techniques are required for particular animals. The following procedures were found to be satisfactory for snakes, lizards and frogs.

In a study of the vertebrae of snakes, the specimens were X-rayed in the following manner: (1) A sheet of film in a cardboard, lead-backed holder was placed on the specimen mount between two metal strips to hold it fast. The mount used was simply a low wooden platform with metal rods and rubber straps, so contrived as to allow the specimen to be clamped down firmly. A lead sheet beneath served to reduce secondary radiation. (2) A thin sheet of lucite (a relatively radio-transparent material) was placed over the film holder to prevent preservatives from reaching the film. (3) Next the specimen was placed, usually ventral side down, across the width of the film and pressed against the lucite sheet and film by means of rubber straps. (4) Lead plates were so arranged as to allow exposure of only the film directly beneath the desired section of the snake. (5) Straight pins were then inserted into the dorsal midline of the specimen to mark off the length exposed. To prevent any confusion by overlap, the caudal pin served as the cranial marker on the next section, as section after section was recorded. (6) Positioning was checked by pressing down along the neural spines and correct-

ing when necessary. Vertical alignment cannot be so checked but can be controlled by flattening the specimen. Tipping in this plane is generally only negligible in snakes, due to the nature of the articulations of the vertebrae. (7) By means of a plumb line, the tube was centered and the exposure made.

Fresh or poorly preserved material was found to be the easiest to handle, since specimens well hardened by preservative tended to bend or tip when straightened out on the mount. Various devices such as laboratory clamps, additional rubber bands or wooden blocks were used to secure hardened specimens. With practice, good alignment could usually be ascertained by "feel" even when the more difficult lateral exposures were made of the specimen on its side. When the neural spines could not be so detected, it was often possible to determine positioning by probing with a fine needle. Full-bodied, cylindrical snakes such as *Typhlops* frequently defied all such measures, and usable exposures were obtained by chance as follows. The snake was tightly rolled in very stiff paper and secured by rubber bands. The roll was placed on the mount and several exposures of the same section were made, slightly rotating the snake each time. High bodied snakes were X-rayed dorsal side down to bring the vertebrae close to the film.

Since the vertebrae are bilaterally symmetrical, correct positioning is indicated on the radiographs by the position of the neural spine. When exposures were obtained indicating improper positioning, the specimen was filmed again and again until enough satisfactory sections were available for a composite record.

Small lizards and frogs were filmed in a single exposure. The following procedure was found to yield the most satisfactory results. If possible, the specimens were eviscerated to afford better definition and to reduce secondary radiation. When the parts of interest were limbs, girdles or column, the specimen was taped dorsal side down to the lucite cover. The skull presented the greatest difficulty. Reducing this complex structure to two dimensions results in a disconcerting array of superimposed shadows. For results suitable for measurement, several pictures are required, each separately positioned for the plane of measurement desired. The curvedness of this structure limited our efforts to the skull roof and the jaws. The skull roof was pictured with the head taped dorsal side down, the elevated body being supported by molding clay. Jaws were recorded in a like manner but with the ventral surface of the head in contact with the lucite sheet.

The two sources of the distortion of a radiographic image affect image size in opposite ways. It is the nature of X-rays to magnify, and the

effect of tipping to reduce. To lessen the combined effect of these factors further, ratios between measures on the same structure were used for the analysis of data in some instances. As long as both of the measures so combined were in the same axis of measurement and were made on the same exposure, the distorting factors were regarded as affecting each equally. Thus the value of the ratio will remain the same regardless of the degree of distortion. The assumption is valid only on small structures, as encountered in these materials, where the distances between the measures entering the ratio are quite small.

The degree of distortion under the conditions of our apparatus and the procedures outlined above were assessed in three ways. The maximum magnifications for the source-film distance employed and for the range of object-film distances encountered were calculated by the geometric relationship previously stated. As an example: for an object 1 cm. in length, raised 2 cm. off the film, 6 cm. from a central ray 122 cm. in length, the image cast will be about 1.02 cm. The conditions stated are the average conditions met in our work for the region of the greatest expected error, namely near the edge of the plate. A distance of 2 cm. off the film for the plane of measurement was commonly met in snakes, but was seldom reached or exceeded by the small lizards and frogs. This maximum magnification amounts to 2 per cent error.

Another assessment was made by filming calipers open to a known distance, raised given distances above the film, and as far from the central ray as any structure X-rayed in these studies. For intervals of 0 to 3 cm., the maximum error was found to be from 0 to 3 percent at the focus-film distance used with the actual specimens. The values thus obtained were in agreement with the theoretical expectations.

The conclusive assessment was made by X-raying a specimen, then cleaning or clearing, and measuring the actual object of study. This trial is far more revealing since it can be run under the actual conditions employed and the combined factors of distortion are manifested. A range of 1.5 to 3 percent distortion was obtained in tests of the material used in these studies. Since none of the assessments of distortion revealed an error exceeding the error in measurement, their effect was neglected.

The correct combination of the variables of kilovoltage, milliamperage and time for technically correct exposures must be uniquely determined for the distances, equipment and materials employed. The rules of the game are set forth in numerous manuals and texts. We have found the excellent Eastman Kodak booklets (1946, The fundamentals of radiography; 1947, Radiography in modern industry) adequate for all our needs.

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Our laboratory is equipped with a Picker Dental Unit (tungsten target) which fulfills most of our requirements. Almost all of the exposures used in the studies of small reptiles and amphibians were made at 50 kilovolts, 10 milliamps, at one to three seconds for a film-focus distance of 122 cm. The film used was 5" by 7" Kodak No-Screen X-Ray film. Measurements were made on a special light box equipped with a cross-hair scanner travelling on a vernier scale.

In view of the assessments of distortion and the consistency of the results of the studies employing these techniques, it is concluded that radiographs can be satisfactorily used in quantitative studies of skeletal variations in small reptiles and amphibians.—RALPH G. JOHNSON, *Laboratory for the Study of Evolution, Walker Museum, University of Chicago, Chicago, Illinois.*

OBSERVATIONS ON THE IDENTITY OF THE SALAMANDER *PLETHODON HULDAE*.

—On August 31, 1954, while traveling the Skyline Drive in the Blue Ridge Mountains of Virginia, Charles F. Walker, my wife Mary, and I had the opportunity to collect at and near the type locality of *Plethodon hulae* Grobman. According to the type description (1949, Proc. Biol. Soc. Washington, 63: 135-42), two species of Small Plethodons occur in this area: *Plethodon cinereus* in its striped phase, and a very similar species with a dark dorsum heavily flecked with silver, *Plethodon hulae*. As described, the essential difference between *P. hulae* and the dark phase of *P. cinereus* (which according to Grobman's account is not known from the area) is the heavy silvery flecking of *P. hulae*, a characteristic that disappears after a short time in preservative. *P. hulae* is discussed in the description, however, as being more closely related to members of the *P. welleri* species group of Small Plethodons (Grobman, 1944, Annals New York Acad. Sci., 45 (7): 261-316) than it is to *P. cinereus*.

We secured a series of 55 Small Plethodons on Hawksbill Mountain, Madison County, the type locality of *P. hulae*, along the foot trail from the Skyline Drive at an altitude of 3,375 feet to very near the summit at 4,035 feet. Striped individuals numbered 43; dark individuals, 12. Despite this unbalanced ratio, the altitudinal distributions of dark and striped animals were practically identical. Twice the two forms were taken under the same piece of cover. Farther north on the Skyline Drive at Hemlock Springs on Stony Man Mountain, at altitudes of approximately 3,200 to 3,300 feet, we collected 29 specimens. Here the ratio of striped individuals to dark ones was much higher than at Hawksbill Mountain (26 to 3). At neither locality did we observe any difference in habitat preference or in behavior between the two forms. Both series

are deposited in the University of Michigan Museum of Zoology (UMMZ), under catalogue numbers 110861-5.

Subsequent examination of these series revealed that the dark individuals corresponded in all particulars to the form called *Plethodon hulae*. However, it also showed that, except for light red to yellow middorsal coloration, the striped specimens were indistinguishable from the dark animals. Flecking was conspicuous in most of the specimens in the areas of dark coloration, particularly on the tail, but was also to be seen, with proper lighting, in the fields of red to yellowish ground color in striped individuals. The actual color of this "silvery" flecking varied from brassy green to gold to silvery white, depending to some degree on lighting, background color, and length of time in preservative, but the color of the macroscopically conspicuous spots was usually silvery to dull white. There was considerable variation in amount of flecking, a few individuals having almost none.

At Hemlock Springs, about an inch below the surface in a well rotted log which had settled to ground level, a yellow-striped female was found curled about four eggs. This lot now bears catalogue number UMMZ 110861. Upon preservation these closely attached eggs were observed to contain very advanced embryos which moved actively. Under a binocular microscope it can be seen that one of the embryos has a broad light dorsal stripe similar to the presumed female parent, while the other three clearly represent the dark colored form.

From these observations, it seems obvious that the dark Small Plethodon and the striped Small Plethodon inhabiting this area of the Blue Ridge of Virginia are merely color phases of a single species.

Reputedly, the essential departure of *P. hulae* from *Plethodon cinereus* is the heavy flecking on the dorsum. However, the variability of this character in the two series we collected at and near the type locality of *P. hulae* was great, and practically the entire range of ephemeral coloration in them was matched by selected freshly preserved individuals of *P. cinereus* from Ann Arbor, Washtenaw County, Michigan. Even the eye coloration in these widely separated samples was the same. Further, Neil Richmond of the Carnegie Museum has informed me (*in litt.*) that recent comparisons of living material indicate that a series of *P. cinereus* from Butler County, northwestern Pennsylvania, exceed animals from Stony Man Mountain in both profusion and density of flecking. He moreover noted that the amounts of flecking on individuals are apparently subject to short-term changes, a source of variation which also obtains in living Michigan specimens of *P. cinereus*. Gross microscopic study reveals that the kind of coloration seen

is influenced by positional relationships of the guanophores and other skin structures (capillaries, melanophores, glands), and the apparent changes in amount may simply reflect displacements of position or movement within chromatophores. In this connection, it was noticed that the relatively large dorsal white spots appear to be derived from the small iridophores by superficial concentration, as transitional kinds can be found. These types do not often cap skin glands as does the guanophore pigmentation of the sides, but usually they lie between the glands (for which reason iridophores in profusion appear as reticulate patterns), and to some extent beneath the glands, a condition most easily seen in striped individuals.

Considering these observations, I am of the opinion that the Small *Plethodon* species of the Blue Ridge of Virginia under discussion is *Plethodon cinereus*, and that the recognition of two species groups of Small *Plethodons*, the *P. cinereus* group and the *P. welleri* group, on the basis of ephemeral flecking proportions (Grobman, 1944, *loc. cit.*) does not reflect a natural division.—GEORGE B. RABB, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

LONGEVITY OF SNAKES IN CAPTIVITY IN THE UNITED STATES AS OF JANUARY 1, 1955.—This list contains what records are available to us. We would like to hear from anyone having better records, or ten-year records of other species. We intend to bring the list up to date each year as of the first of January. Only the oldest snake of each species or subspecies is listed. Age is given in years (second column) and months (third column), and the source of the record is included (fourth column). An asterisk indicates that the specimen was alive on January 1, 1955. Symbols used are as follows: AM = American Museum of Natural History, BdZ = Brookfield Zoo, BxZ = Bronx Zoo, GOW = Grace O. Wiley, GPM = George P. Meade, JGM = John G. Moore, NCM = North Carolina State Museum, PZ = Philadelphia Zoo, RMS = R. M. Stabler, SDZ = San Diego Zoo, SIZ = Staten Island Zoo, SLZ = St. Louis Zoo, TC = Tabor College, WZ = Washington Zoo.

<i>Aghistrodon contortrix laticinctus</i> *	14	7	SDZ
<i>Aghistrodon contortrix mokeson</i> *	18	6	SDZ
<i>Aghistrodon piscivorus</i>	18	11	RMS
<i>Boa constrictor constrictor</i>	12	3	PZ
<i>Boa constrictor imperator</i> *	17	3	SDZ

<i>Boiga dendrophila</i>	11	9	SLZ
<i>Corallus annulatus</i>	12	4	PZ
<i>Corallus enydris cooki</i>	14	3	SDZ
<i>Crotalus adamanteus</i>	14	9	NCM
<i>Crotalus atrox</i> *	18	7	SDZ
<i>Crotalus basiliscus basiliscus</i>	10	1	SDZ
<i>Crotalus cerastes laterorepens</i>	12	8	SDZ
<i>Crotalus durissus durissus</i>	12	0	SLZ
<i>Crotalus horridus horridus</i>	15	7	SDZ
<i>Crotalus mitchelli pyrrhus</i>	11	9	SDZ
<i>Crotalus ruber ruber</i> *	13	4	SDZ
<i>Crotalus tortugensis</i> *	17	9	SDZ
<i>Crotalus unicolor</i>	13	6	SDZ
<i>Crotalus viridis helleri</i> *	17	10	SDZ
<i>Crotalus viridis viridis</i> *	16	1	SDZ
<i>Dendroaspis viridis</i>	11	3	SLZ
<i>Drymarchon corais couperi</i> *	22	4	JGM
<i>Elaphe guttata guttata</i>	21	9	PZ
<i>Elaphe obsoleta obsoleta</i>	16	0	AM
<i>Elaphe obsoleta quadrivittata</i> *	17	4	SDZ
<i>Elaphe obsoleta spiloides</i> *	13	5	RMS
<i>Epicrates angulifer</i> *	16	2	SDZ
<i>Epicrates cenchria crassus</i>	14	6	SIZ
<i>Epicrates cenchria maurus</i>	27	4	BxZ
<i>Epicrates striatus</i>	16	0	PZ
<i>Eunectes barbouri</i>	13	11	PZ
<i>Eunectes deschauenseei</i>	13	10	PZ
<i>Eunectes murina</i>	28	0	WZ
<i>Helicopsis schistosus</i>	12	3	PZ
<i>Hemachatus haemachatus</i>	11	9	BdZ
<i>Lampropeltis dolia amaura</i> *	18	7	GPM
<i>Lampropeltis dolia annulata</i> *	14	5	SDZ
<i>Lampropeltis getulus brooksi</i>	10	0	SDZ
<i>Lampropeltis getulus californiae</i>	14	10	SDZ
<i>Lampropeltis getulus floridana</i> *	11	6	SDZ
<i>Lampropeltis getulus holbrooki</i> *	11	8	SDZ
<i>Lampropeltis zonata multifasciata</i>	13	6	SDZ
<i>Lichanura roseofusca roseofusca</i>	12	0	SDZ
<i>Loxocemus bicolor</i> *	12	0	PZ
<i>Masticophis flagellum piceus</i> (black)	11	2	SDZ
<i>Masticophis flagellum piceus</i> (red)	12	2	SDZ
<i>Masticophis flagellum testaceus</i>	13	5	SDZ
<i>Naja melanoleuca</i> *	26	3	SDZ
<i>Naja naja</i>	12	4	PZ
<i>Naja naja atra</i>	10	3	BdZ
<i>Naja nigricollis</i> *	20	2	BdZ
<i>Naja nivea</i>	15	3	SDZ
<i>Ophiophagus hannah</i>	11	10	GOW
<i>Pituophis catenifer affinis</i>	13	4	SDZ
<i>Pituophis catenifer annexens</i>	15	2	SDZ
<i>Pituophis catenifer annexens</i> (albino)*	13	7	SDZ
<i>Pituophis catenifer catenifer</i>	11	0	SDZ
<i>Pituophis melanoleucus melanoleucus</i> *	14	5	SDZ
<i>Python curtus curtus</i> *	18	10	SDZ
<i>Python molurus bivittatus</i> *	18	7	SDZ
<i>Python molurus molurus</i>	13	0	PZ
<i>Python reticulatus</i>	20	0	SLZ
<i>Python sebae</i> *	18	1	PZ
<i>Rhinocentillus lecontei lecontei</i> *	13	1	SDZ
<i>Sistrurus catenatus</i>	14	0	TC
<i>Ungaliophis continentalis</i>	17	8	GOW

—C. B. PERKINS, *Zoological Society of San Diego, San Diego, California.*

REVIEWS AND COMMENTS

FISHES OF THE WESTERN NORTH ATLANTIC / PART TWO / SAWFISHES, GUITARFISHES, SKATES AND RAYS [AND] CHIMAERIDS. By Henry B. Bigelow and William C. Schroeder. Mem. Sears Found. Mar. Res., No. 1, Pt. 2, "1953" [distributed in late 1954]: xv + 588, 2 maps, 134 figs. \$15.00 (cloth). Part 2 is delivered from Denmark; therefore adequate time for receiving it by mail should be allowed. Postal charges (\$1.25) are not added to the price of the book when payment is made with the order.—All that was said of the first part of this monumental treatise (in COPEIA, 1949: 155-7)—almost entirely in high commendation and in deep appreciation—applies with equal force to this eagerly awaited continuation, which covers the Batoidea (pp. 1-514, 123 figs.) and the Holocephali (pp. 515-62, 11 figs.). Both sections are enriched by the results of recent discoveries, largely by the same authors. Their analysis of the unexpectedly rich and diverse ray fauna collected during the last few years in the Gulf of Mexico is an outstanding ichthyological contribution. All species referred to their genus *Breviraja* belong to this fauna, and of the 7 species, 6 have been described by Bigelow and Schroeder. Here also belong 2 of the 4 species of their genus *Cruiraja*, in which the outer lobe of the pelvis is modified into a separate digitiform appendage, perhaps overcautiously suggested as of ambulatory function. Another and even more bizarre novelty from the Gulf is 1 of the 3 species of rays referred to a separate family Anacanthobatidae, with similar pelvis, but without dorsal fins, and provided with a filamentous snout.

Excellent figures, emphasizing diagnostic structural details, again augment the usefulness as well as attractiveness of the treatise. In design and execution the book is exemplary.

Especially useful is the expansion of the carefully prepared simplified identification keys to cover almost all known genera from the entire world, and, for certain genera, all known species from the world, or from some enlarged portion of the Atlantic. The preparation of the book obviously led the authors into a critical worldwide review, but they have wisely been conservative in withholding material not thoroughly covered by available data.

Throughout the volume, in duly systematized form, there is included a great wealth of published and original data on ecology, distribution, habits, reproduction, size, etc. In a seven-page addendum on *Raja erinacea*, Merriman, Olsen, Wheatland, and Calhoun summarize their life-history study of

Raja erinacea. The entire coverage is remarkably complete, in text as well as in the annotated synonymies.

A mighty firm foundation has been provided for further contributions. Again I wish to say: superlatively well done!—CARL L. HUBBS, *Scripps Institution of Oceanography, University of California, La Jolla, California*.

ASPECTS OF DEEP SEA BIOLOGY. By N. B. Marshall. Philosophical Library, New York: 1-380, 103 figs., 5 col. pls. \$10.00.—Marshall tells us that his task was "to utilize present knowledge and some of my own unpublished work to build up, chapter by chapter, an integrated account of life in deep oceanic waters." The hitherto concealed part of "the sea around us" has always inspired interest and wonder in layman and scientist alike. It long resisted exploration, and is only now beginning to be revealed. The clearer view that the fantastic bathyscaphe has opened up has been too new even for this book. Through such visible exploration, as well as through the application of recently developed instruments and collecting gear and through experiments, we are on the threshold of answers to fundamental questions that the author in this book raises in the series of excellent essays on deep-sea life. His treatment has been most thorough and authoritative in respect to the animals on which he himself has worked, namely those of the plankton and the bathypelagic fishes, but the whole discussion is scholarly and suffused with suggested explanations and ideas for further consideration.

The book starts with a well informed history of exploration into deep-sea biology and a discussion of the means for such exploration. There follow rather restricted but informative and up-to-date accounts of the deep-sea environment and of oceanic plants. A well illustrated general chapter on animal life in the deep sea then completes the background for the thoughtful discussions that follow—on deep-sea food chains, on vertical patterns of mid-water life, on adaptations for flotation, on the sense organs of deep-sea fishes, on deep-sea sound, on bioluminescence (one of the longer and most useful chapters), on the fascinating life-history adaptations, and on some aspects of the biogeography of deep-sea animals. The last chapter pays particular attention to more or less ecological segregation, on the postulate that no two species of identical life ways can continue in the same niche. Little is said about the regional patterns of distribution that some deep-sea animals clearly exhibit, or about the

age of the deep-sea fauna, or of the special problems involved.

The reader gets the feeling that the subject is alive and dynamic. He is reminded of this circumstance by such passages as: "we have little precise information on this question, yet this is surely a most promising field for future work"; "clearly the growth of oceanography as a unified science of the seas must always depend on the closest integration of its physical and biological aspects"; "the ocean is full of surprises, particularly for those who make up their minds too quickly"; "evidently there is more to be learned"; "but of this little is known"; "this is another aspect for further study."

This is a book well designed for students of biology and especially for all biologists who look beyond the boundaries of their own specialties. For investigators of deep-sea life it will be of immense value, and a frequent source of ideas and of inspiration for further research.—CARL L. HUBBS, *Scripps Institution of Oceanography, University of California, La Jolla, California*.

THE ELEMENTARY CHEMICAL COMPOSITION OF MARINE ORGANISMS. By A. P. Vinogradov. Translated from Vinogradov's original Russian by Julia Efron and Jane K. Setlow, with bibliography edited and newly enlarged by Virginia W. Odum. *Mem. Sears Found. Mar. Res.*, 2, "1953" [1954]: xiv + 647. \$17.00.—In the preface of this monumental treatise G. E. Hutchinson, who himself obviously had a hand in its preparation, states that the book "constitutes one of the most important contributions that has yet been made to the study of the border line between biology and geochemistry." Not only geochemists, but also oceanographers, paleontologists, zoologists, ecologists, and other scientists, will welcome and use this great compilation, with a feeling of gratitude toward the Russian author and to the American team which brought it into the present form. Sarah B. Wheatland is given credit for revising the fish classification, and the section on fishes was examined by Grace E. Pickford, who provided numerous references to recent work.

In some respects the treatment seems a little behind certain spectacular recent advances or was not intended to cover such items as the natural distribution of radioactive elements, such as C_{14}

and O_{18} that tell age and water temperature, respectively. There is little on the calcite-aragonite ratios in shells. One of the most serious deficiencies, which perhaps arose in part from the systematized arrangement, is the almost complete lack of total analyses of all the elements in single species.

The Russian original, which was published in three parts (in 1935, 1937, and 1944), apparently made no forced claims for Russian priorities in discovery. Nor do Russian references appear to have been unduly selected.

The greater portion of the text is devoted to a compilation of the literature, with some new data added, all well tabulated, and considerably integrated with function, productivity, the fossil record, etc. The data on fishes are particularly extensive, covering pages 463 to 566.

The two final chapters treat the regulating influence of ocean salt on the chemical composition of marine organisms, and fundamental changes in the elementary composition of marine organisms during geological time. An enormous bibliography is appended.

This is a companion volume to the *Fishes of the Western North Atlantic* and shows the same high standard of design, paper, composition, and editing. One wonders, however, whether less sumptuous typography and margins might have reduced the subsidized price or have increased the edition, or both.—CARL L. HUBBS, *Scripps Institution of Oceanography, University of California, La Jolla, California*.

ZOOLOGICAL RECORD. The Zoological Society of London. Vol. 90, 1953. Sect. 15 (Pisces), April, 1955: pp. 1-90. Price, 7s. Sect. 16A (Amphibia), April, 1955: pp. 1-70. Price, 7s 6d. Sect. 16B (Reptilia), May, 1955: pp. 1-88. Price, 4s.—The section on Pisces has 1,133 titles; the section on Amphibia titles is 25 pages long; and the section on Reptilia titles is 22 pages long. Each section is divided into three parts: I, a list of titles arranged alphabetically by author; II, a subject index, with numerous subdivisions; and III, a systematic index, subdivided by orders and families. Orders for copies of the Zoological Record should be sent to the Director, Zoological Society of London, Regent's Park, London, N.W.1, England.

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EDITORIAL NOTES AND NEWS

FINANCIAL REPORT FOR CALENDAR YEAR 1954

By Coleman J. Goin, Treasurer

CHECKING ACCOUNT

Balance on hand, Citizen's Bank of Gainesville, Jan. 1, 1954. \$3,992.90

Receipts

Memberships Received

Current dues for 1954.	\$1,051.37	
Back dues for 1953 and before.	9.00	
Advance dues for 1955 and beyond.	3,575.84	
		<hr/>
		4,636.21

Subscriptions Received

Current, for 1954.	715.90	
Back, for 1953 and before.	6.00	
Advance, for 1955 and beyond.	1,428.36	
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		2,150.26

Back numbers of COPEIA sold (from Publications Secretary).	830.55
Interest, Stoye Fund Bonds.	75.00
Interest, Endowment Bonds.	50.00
Contributions.	2.00
Check List.	3.50
Charges for use of Mailing List.	20.00
Payment for Reprints.	16.80
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Total.	\$11,777.22

Expenditures and Disbursements

Cost of publication of COPEIA

1954, no. 1.	\$1,562.27	
1954, no. 2.	1,795.62	
1954, no. 3.	1,674.28	
1954, no. 4.	1,593.28	
		<hr/>
		\$6,625.45

Printing.	507.44
Stenographic Services, Secretary, Gainesville.	247.50
Social Security.	3.07
Postage and Incidentals	
Secretary, Gainesville.	200.00
Editor, Ann Arbor.	103.14
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	303.14

Contributions

Remittance of 40 pounds to Zoological Society to assist in publication of "Zoological Record".....	113.60
Dues, American Institute of Biological Sciences.....	667.00
Reimbursement, Treasurer for 1953 bond.....	5.00
Purchase of COPEIA for Secretary.....	3.75
Guests at ASIH banquet.....	15.00
Bank charges.....	.94
Purchase of typewriter for Secretary.....	50.99
Refund for overpayment.....	6.00
Purchase of Check List.....	3.50
Stoye Prizes awarded at Annual Meeting	
JACK RANDALL (Ichthyology).....	25.00
WALTER AUFFENBERG (Herpetology).....	25.00
JOHN CRENSHAW (Herpetology).....	25.00
	<hr/>
	75.00
Total expenditures.....	8,627.38
Balance on hand, Citizen's Bank, December 31, 1954.....	3,149.84
Total.....	<hr/>
	\$11,777.22

ENDOWMENT FUND

Balance on hand, First Federal Savings and Loan Association, January 1, 1954.....	\$733.15
Received from members for life memberships.....	395.00
Received from sale of Check List.....	1,328.80
Interest on Savings Account.....	34.55
Interest on Bonds.....	50.00
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Balance on hand, First Federal Savings and Loan Association, December 31, 1954.....	\$2,541.50

REVOLVING RESEARCH FUND

Balance, on hand, Florida Bank of Gainesville, January 1, 1954.....	\$420.25
Repayment from grantee.....	110.00
Gift.....	5.00
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Balance on hand, Florida Bank of Gainesville, December 31, 1954.....	\$535.25

The above report was approved, March 4, 1955, by an auditing committee composed of WALTER AUFFENBERG, JOHN C. BRIGGS, and ARCHIE CARR, Chairman.

News
Notes

THE Southeastern Division of the American Society of Ichthyologists and Herpetologists will hold its next annual meeting at Highlands Biological Station, Highlands, North Carolina, on October 7 and 8, 1955.

DR. CURT KOSSWIG has resigned his position with the University of Istanbul, Turkey, to become director of the Zoologisches Staatsinstitut of the University of Hamburg (Born Platz, Hamburg, Germany).

DR. ENRICO TORTONESE has resigned from the University of Torino, Italy, to accept the director-

ship of the Museo Civico di Storia Natural, Genova, Italy (Via Brigata Liguria 9).

DR. WILLIAM C. BECKMAN has resigned from his position with the Fish and Wildlife Service, U. S. Dept. of Interior, to join the Food and Agricultural Organization of the United Nations, to be stationed at Damascus, Syria. His first assignment with the FAO will be a survey of the fresh-water fisheries of Syria.

Recipients of John Simon Guggenheim Memorial Fellowships for 1955 are: CHARLES M. BOGERT, to study thermoregulation in reptiles; and DR. ERNEST A. LACHNER, to study tropical marine fishes.

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

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Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

Back numbers of COPEIA, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College Huntington, West Virginia. Prices will be furnished on application.

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Original contributions, not to be published elsewhere, are alone acceptable.

Reprints are furnished at approximate cost.

Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author at the discretion of the Editors.



